

DOCTOR OF PHILOSOPHY

Understanding supply chain disruption risk
with the aid of social networks and
information flows analysis

Amrik Singh

2013

Aston University

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**UNDERSTANDING SUPPLY CHAIN DISRUPTION RISK WITH THE AID OF
SOCIAL NETWORKS AND INFORMATION FLOWS ANALYSIS**

AMRIK SINGH

Doctor of Philosophy

ASTON UNIVERSITY

March 2013

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Aston University

**Understanding Supply Chain Disruption Risk With The Aid Of Social Networks
And Information Flows Analysis**

**Amrik Singh
Doctor of Philosophy, March 2013.**

Thesis Summary

Supply Chain Risk Management (SCRM) has become a popular area of research and study in recent years. This can be highlighted by the number of peer reviewed articles that have appeared in academic literature. This coupled with the realisation by companies that SCRM strategies are required to mitigate the risks that they face, makes for challenging research questions in the field of risk management. The challenge that companies face today is not only to identify the types of risks that they face, but also to assess the indicators of risk that face them. This will allow them to mitigate that risk before any disruption to the supply chain occurs. The use of social network theory can aid in the identification of disruption risk. This thesis proposes the combination of social networks, behavioural risk indicators and information management, to uniquely identify disruption risk.

The propositions that were developed from the literature review and exploratory case study in the aerospace OEM, in this thesis are:

- By improving information flows, through the use of social networks, we can identify supply chain disruption risk.
- The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

The propositions were further explored through four focus group sessions, two within the OEM and two within an academic setting.

The literature review conducted by the researcher did not find any studies that have evaluated supply chain disruption risk management in terms of social network analysis or information management studies. The evaluation of SCRM using these methods is thought to be a unique way of understanding the issues in SCRM that practitioners face today in the aerospace industry.

Keywords

Supply Chain Risk Management, Social Networks, Push/Pull Information Management, Aerospace Supply Chain.

Dedication

“Dedicated to my beloved jaan, who has helped and supported me through
times of happiness and sadness.”

Publications

Singh, A., Bennett, D. April 2011. The management of information to identify supply chain disruption risk can be explored using push and pull concepts. Proceedings in POMS Reno, USA.

Singh, A., Bennett, D. May 2010. Predicted and Routine Supply Chain Risks are More Important than Unknown Risks: Managerial Perspectives on Supply Chain Disruption Risk. (Presentation only). POMS Vancouver, Canada.

Brookes, N., Singh, A. May 2009. A comparison of supply chain risk perceptions in Original Equipment Manufacturers and Tier One suppliers: A case-study in the aerospace industry. Proceedings in POMS Florida, USA.

Singh, A., Brookes, N. June 2009. An evaluation of supply chain risk management tools used by a manufacturer in the aerospace industry. Proceedings in EurOMA Gothenburg, Sweden.

Brookes, N., Singh, A. May 2008. Social Networks and Supply Chains. Proceedings in POMS San Diego, USA.

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List of Contents

THESIS SUMMARY	2
KEYWORDS.....	2
DEDICATION	3
ACKNOWLEDGEMENTS	4
PUBLICATIONS	5
LIST OF CONTENTS	6
LIST OF FIGURES	13
LIST OF TABLES	14
LIST OF ACRONYMS	15
CHAPTER ONE - INTRODUCTION	17
1.1 SUMMARY OF PROJECT.....	21
1.1.1 <i>The Aim of the Project for the Academic Collaborator</i>	21
1.2 BACKGROUND OF OEM AND AEROSPACE SECTOR	23
1.3 METHODOLOGY	27
1.4 RESEARCH PROPOSITIONS.....	27
1.5 CONTRIBUTION.....	28
1.6 OVERVIEW OF CHAPTERS	29
1.7 CHAPTER SUMMARY	32
CHAPTER TWO - LITERATURE REVIEW	33
2.0 INTRODUCTION.....	33
2.1 ANALYSIS OF CORE LITERATURE	33
2.2 SUPPLY CHAIN MANAGEMENT	34
2.3 RISK, RESILIENCE AND VULNERABILITY	36

2.4 RISK AND SUPPLY CHAINS	39
2.5 AEROSPACE SUPPLY CHAINS	59
2.6 SUPPLY CHAIN KNOWLEDGE MANAGEMENT	63
2.7 SOCIAL NETWORK PERSPECTIVE.....	68
2.8 USING SOCIAL NETWORK THEORY IN A SUPPLY CHAIN CONTEXT	75
2.8.1 <i>Using Social Network Concepts to Model Holistic Complex Supply Chains</i>	77
2.9 TYPOLOGY OF TYPES OF TIES AMONGST PERSONS STUDIED IN THE SOCIAL NETWORKS LITERATURE.....	81
2.10 PUSH AND PULL INFORMATION AND KNOWLEDGE MANAGEMENT	83
2.10.1 <i>Information Push and Pull</i>	85
2.11 LITERATURE RESEARCH FINDINGS AND ISSUES	86
2.12 DISCUSSION OF THEMES.....	89
2.13 HOW DOES THE LITERATURE REVIEW LEAD TO EXPLORATORY THEMES?	90
2.14 CHAPTER SUMMARY	92
CHAPTER THREE - THE RESEARCH METHODOLOGY FRAMEWORK	94
3.0 INTRODUCTION.....	94
3.1 METHODOLOGY SUMMARY	94
3.2 PHILOSOPHICAL UNDERPINNINGS OF RESEARCH	98
3.2.1 <i>Evaluation of the Discipline</i>	98
3.2.2 <i>Research Paradigms</i>	100
3.2.3 <i>Research Methodologies - In Operations Management</i>	103
3.2.4 <i>Evaluation of Research Paradigms Discussion</i>	105
3.2.5 <i>Comparison of Qualitative and Quantitative Research Designs</i>	106
3.2.6 <i>Qualitative Research</i>	106
3.2.7 <i>Quantitative Research</i>	107
3.2.8 <i>Conclusion</i>	108

3.2.9 Arguments For and Against Methods Chosen.....	108
3.3 INDUCTIVE VERSUS DEDUCTIVE RESEARCH APPROACH	109
3.4 LITERATURE REVIEW METHODS	110
3.4.1 Identification of Relevant Areas of Research	111
3.4.2 Key Areas That the Literature Aims to Look at.....	111
3.4.3 Keywords.....	112
3.4.4 Search Engines	112
3.4.5 Key Strings and Hit Rate on Search Engines.....	113
3.4.6 Selection of Studies	113
3.5 CASE STUDY BACKGROUND	113
3.5.1 Detailed Case Study Design	113
3.5.2 Problems and Limitations.....	116
3.6 INTERVIEW METHODS	117
3.6.1 Interview Sampling Strategy	119
3.6.2 Interview Sample Composition.....	119
3.6.3 Types of Interview Questions.....	121
3.6.4 Six Steps of Analysis	122
3.7 THEORETICAL SATURATION OF INTERVIEWS	123
3.8 ANALYTIC STRATEGY IN CASE STUDIES	125
3.9 FOCUS GROUPS	126
3.9.1 What are Focus Groups?.....	127
3.9.2 The Use of Focus Groups Compared to Other Methods	128
3.9.3 The Role of Focus groups.....	128
3.9.4 Potential and Limitations.....	129
3.9.5 The Organisation of Focus Groups	130
3.9.6 The Role of the Moderator	131
3.10 FOCUS GROUPS SUMMARY	133
3.11 FOCUS GROUP AND INTERVIEW ANALYSIS.....	135

3.11.1 <i>Analysis Choices</i>	135
3.11.2 <i>Coding</i>	136
3.13 ETHICAL ISSUES	140
3.14 GENERALISABILITY, RELIABILITY AND VALIDITY	141
3.14.1 <i>Reliability</i>	141
3.14.2 <i>Validity</i>	142
3.14.3 <i>Generalisability</i>	143
3.15 CHAPTER SUMMARY	143
CHAPTER FOUR – FINDINGS OF EXPLORATORY CASE STUDY.....	145
4.0 INTRODUCTION.....	145
4.1 TYPES OF RISK.....	145
4.2 BEHAVIOURAL INDICATORS OF RISK.....	147
4.2.1 <i>Mapping Risks and Risk Triggers</i>	151
4.3 IMPORTANCE OF RISK IDENTIFICATION THROUGH SOCIAL NETWORKS.....	153
4.3.1 <i>Current Perceptions of Social Networks</i>	154
4.3.2 <i>Are the OEM's Social Contacts Sufficient</i>	155
4.4 CONTACTS IN SUPPLIER COMPANIES	158
4.5 CURRENT PROCESS OF RISK IDENTIFICATION AND MITIGATION.....	159
4.6 THOUGHTS ON DEVELOPING SOCIAL NETWORKS.....	161
4.7 THE DEPTH OF SOCIAL NETWORK APPLICATION.....	163
4.8 ARE SOCIAL CONTACTS A GOOD WAY OF IDENTIFYING RISK?	165
4.9 PROBLEMS OF SHARING INFORMATION	167
4.10 SOLUTIONS TO IDENTIFY RISK	170
4.11 PUSHING AND PULLING INFORMATION	171
4.12 FEATURES OF NETWORK.....	173
4.12.1 <i>Size</i>	173
4.12.2 <i>Centrality</i>	174

4.12.3	<i>Reachability</i>	174
4.12.4	<i>Diversity</i>	174
4.12.5	<i>Openness</i>	174
4.12.6	<i>Stability</i>	175
4.12.7	<i>Density</i>	176
4.12.8	<i>Relational Ties</i>	176
4.13	OUTSOURCING AND RISK	177
4.14	A COMPARISON OF SUPPLY CHAIN RISK PERCEPTIONS IN THE OEM AND TIER ONE SUPPLIERS.....	180
4.14.1	<i>The Investigation Methodology</i>	182
4.14.2	<i>The Case Study Design</i>	182
4.14.3	<i>Perceptions of Supply Chain Risk in the OEM</i>	184
4.14.4	<i>Perceptions of Supply Chain Risk in Tier One Suppliers</i>	186
4.14.5	<i>Conclusions of Perceptions Study</i>	187
4.15	CHAPTER SUMMARY	188
CHAPTER FIVE - PROPOSITIONS/ FINDINGS ABOUT PROPOSITIONS.....		190
5.0	INTRODUCTION	190
5.1	PROPOSITIONS.....	190
5.2	WHY DID THE EXPLORATORY THEMES LEAD TO THE PROPOSITIONS?.....	190
5.3	FINDINGS ABOUT PROPOSITIONS.....	191
5.4	PURPOSE AND AIMS OF FOCUS GROUPS.....	192
5.5	KEY FINDINGS FROM FOCUS GROUPS.....	192
5.5.1	<i>Social Networks Used Daily to Identify Risk, But Not Formalised</i>	192
5.5.2	<i>A Combination of Social Network Risk Identification and Risk Identification Through Formal Methods and Tools Needed</i>	196
5.5.3	<i>Predicted and Routine Risks are More Important Than Unknown Ones</i>	199
5.5.4	<i>Need to React to Risk, Based on Individuals</i>	200

5.5.5 Need to React to Risk, Based on Methods and Not Individuals.....	200
5.5.6 Risk Identification Based on Importance of Supplier	201
5.5.7 Care in Closeness of Social Contacts.....	202
5.5.8 Contacts Leave and You Lose Social Network	203
5.5.9 Triggers to Identify Risk	204
5.5.10 Trust Barriers to Social Sharing	205
5.5.11 Pull Better Than Push, to Avoid Information Overload	206
5.5.12 Individuals Will Not Push	207
5.5.13 A Combination of Pushing and Pulling Information Required.....	208
5.6 CHAPTER SUMMARY	211
CHAPTER SIX - DISCUSSION OF FINDINGS	212
6.0 INTRODUCTION.....	212
6.1 EXPLORATORY CASE STUDY	212
6.2 SUPPLIER PERCEPTIONS OF RISK.....	219
6.3 FOCUS GROUP FINDINGS.....	220
6.4 CHAPTER SUMMARY	223
CHAPTER SEVEN – CONCLUSIONS/ FURTHER WORK.....	225
7.0 INTRODUCTION.....	225
7.1 ORIGINAL CONTRIBUTION MADE BY THIS THESIS	225
7.1.1 Conclusions from the Research Propositions.....	229
7.1.2 Theoretical Contribution.....	229
7.1.3. Practical Contribution.....	231
7.2 RELIABILITY.....	231
7.3 VALIDITY	232
7.4 GENERALISABILITY	233
7.5 INTERVIEWER/ MODERATOR BIAS.....	234
7.6 RESEARCH PUBLICATIONS	235

7.7 LIMITATIONS OF RESEARCH.....	235
7.8 FURTHER RESEARCH AND PRACTICE	236
7.9 CHAPTER SUMMARY	237
LIST OF REFERENCES	238
APPENDICES	249
APPENDIX A - CITATION STATISTICS	249
APPENDIX B – CASE STUDY SAMPLE RESEARCH QUESTIONS	252
APPENDIX C - GUIDELINES FOR MODERATOR.....	253
APPENDIX D – INFORMED CONSENT	254
APPENDIX E – EXAMPLE CODED SUPPLY CHAIN INTERVIEW.....	255
APPENDIX F – EXAMPLE THEME AND CODED TEXT	257
APPENDIX G – AN INITIAL SUPPLY CHAIN RISK PILOT STUDY IN A SME IN THE AEROSPACE INDUSTRY	258
APPENDIX H – SUPPLIER RISK RELATIONSHIP MANAGEMENT (SR ² M): A THEORETICAL FRAMEWORK	268
APPENDIX I - THE MANAGEMENT OF INFORMATION TO IDENTIFY SUPPLY CHAIN DISRUPTION RISK CAN BE EXPLORED USING PUSH AND PULL CONCEPTS.	281
APPENDIX J – LIST OF PUBLICATIONS	292

List of Figures

FIGURE 1.1: CHAPTER SUMMARY	31
FIGURE 2.1: THE RELATIONSHIP BETWEEN SUPPLY CHAIN RESILIENCE, SUPPLY CHAIN RISK MANAGEMENT AND SUPPLY CHAIN VULNERABILITY...	37
FIGURE 2.2: A SAMPLE SOCIAL NETWORK MAP	69
FIGURE 2.3: TYPOLOGY OF TIES	81
FIGURE 3.1: RESEARCH METHODOLOGICAL FRAMEWORK	96
FIGURE 3.2: THE RESEARCH UNION	100
FIGURE 3.3: A GENERIC RESEARCH PARADIGMS MODEL IN OPERATIONS MANAGEMENT	103
FIGURE 3.4: RANGE OF METHODOLOGIES IN RESEARCH PARADIGMS.....	104
FIGURE 4.1: THE CASE STUDY PROTOCOL	184

List of Tables

TABLE 2.1: RISK FACTORS.....	55
TABLE 2.2: EXAMPLES OF INTER-ORGANIZATIONAL TIES CROSS-CLASSIFIED BY TYPES OF TIES (ROWS) AND TYPE OF ENTITY INVOLVED (COLUMNS)....	82
TABLE 3.1: FOUR CATEGORIES OF SCIENTIFIC PARADIGMS AND RELATED ELEMENTS.....	101
TABLE 3.2: A FRAMEWORK FOR RESEARCH METHODS IN OPERATIONS MANAGEMENT	104
TABLE 3.3: EIGHT DIMENSIONS OF RESEARCH TRADITIONS.....	108
TABLE 3.4: FIVE COMPONENTS OF RESEARCH DESIGN.....	115
TABLE 3.5: SEVEN STAGES OF INTERVIEW ANALYSIS.....	118
TABLE 3.6: INTERVIEW SAMPLE COMPOSITION.....	120
TABLE 3.7: TABLE OF ANALYSIS TYPES.....	135
TABLE 3.8: TABLE OF THEMES.....	139
TABLE 4.1: TABLE OF RISKS AND INDICATORS.....	152
TABLE 4.2: THE CASE-STUDY DESIGN (C.F. YIN, 2002).....	183
TABLE 4.3: TIER ONE SUPPLIER SAMPLE CHARACTERISTICS	186

List of Acronyms

AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
BBWS	Brake By Wire Systems
CBA	Cost Benefit Analysis
DNBi	Dun and Bradstreet Internet Risk Tool
EPSRC	Engineering and Physical Sciences Research Council
FMEA	Failure Mode Effects Analysis
GVA	Gross Value Added
IM	Information Management
IT	Information Technology
KM	Knowledge Management
KPI	Key Performance Indicators
MAS	Multi Agent Systems
MRO	Maintenance Repair and Overhaul
MSC	Manufacturing Supply Chain
OEM	Original Equipment Manufacturer
RBA	Risk Benefit Analysis
R&D	Research and Development
SBAC	Society of British Aerospace Companies
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operational Reference Model
SCRM	Supply Chain Risk Management
SEM	Structural Equation Modelling
SME	Small and Medium Sized Enterprises

SN	Social Networks
SNA	Social Network Analysis
SPI	Smart Procurement Initiative
TK	Tacit Knowledge
TPIS	Tyre Pressure Indicating Systems
UKAI	United Kingdom Aerospace Industry

Chapter One - Introduction

The main aim of the research is how to identify disruption risk in an aerospace supply chain through the examination of information flows through social networks. The social network perspective will be used to discuss the flows of information in the supply chain. The examination of information flows will also be explored in terms of push and pull information management. This research was undertaken under the auspices of an EPSRC/Advantage West Midlands collaborative CASE studentship, between an aerospace original equipment manufacturer (OEM) and Aston University.

The aerospace organisation conceptualised the idea and aim of the research based on a problem that they had in the supply chain. This was a second tier supplier becoming bankrupt, and the notification of the bankruptcy through the social networks of the OEM's employees. This led the OEM management team wanting to research into how such information came to light and how future disruption risks could be identified and mitigated. A CASE studentship was then developed between the EPSRC, Advantage West Midlands, the aerospace OEM and Aston University. The research studentship was advertised on Aston Universities Careers Website, to which the researcher of this thesis applied, and was interviewed and successfully accepted to commence the doctorate studentship.

Supply Chain Risk Management (SCRM) has become a popular area of research and study in recent years (Singh and Brookes, 2008a). This can be highlighted by the number of peer reviewed articles that have appeared in academic literature (further explored in chapter 2). Our world is increasingly uncertain and vulnerable.

Over the last 10 years, we have witnessed many types of unpredictable disasters, including terrorist attacks, wars, earthquakes, economic crises, devaluation of currencies in Asia, SARS, tsunamis, strikes, computer virus attacks, etc. (Tang, 2006). This coupled with the realisation by companies that SCRM strategies are required to mitigate the risks that they face, makes for challenging research questions in the field of risk management. The challenge that companies face today is not only to identify the types of risks that they face, but also to assess the indicators of risk that face them. This will allow them to mitigate that risk before any disruption to the supply chain occurs. Risk identification is the fundamental stage of the entire risk management process (Giannakis and Louis, 2011). It is proposed in this thesis that the use of the social network perspective theory in practice will aid in the identification of disruption risk.

The strategy is also to assess the management of information that allow companies to gather information which will allow them to mitigate that risk before any disruption to the supply chain occurs. Information management (IM) is the collection and management of information from one or more sources and the distribution of that information to one or more audiences (Singh and Bennett, 2011). There is a lack of models in analysing the supply chain risk associated with information flows, possibly due to the omission of appropriate modelling techniques in this area (Tang and Nurmaya, 2011).

The concept of 'social networks' is well established. Social networks have been used as constructs in social sciences since the 1950s (e.g. Hayashi, 1957; Mouton et al., 1955). The features of the social network perspective have been summarised by Wasserman and Faust (1996). The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors

allow the transfer of resources: physical or information based. Network structures are developed from combinations of these 'dyadic' relational ties between two actors. Network models explain structures in terms of lasting patterns of relations between actors. Combinations of relational ties can form 'paths' through the network by which non-adjacent actor nodes can communicate. The mathematical analysis of networks, either in the form of sociomatrices or topological networks, has formed the basis of a research perspective known as Social Network Analysis (SNA) that has been documented exhaustively by Wasserman and Faust (1996). Seminal work in applying concepts of social networks to management issues was undertaken by Krackhardt and Hanson (1993).

Supply chain risk is defined as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety (Zsidisin, 2003). Chopra and Sodhi (2004) go on to argue that there are nine categories of risk: Disruptions, Delays, Systems, Forecast, Intellectual Property, Procurement, Receivables, Inventory, and Capacity. The disruption to material flows anywhere in the supply chain. Examples include, natural disasters, labour strikes, fires and terrorism have halted the flow of materials. This disruption can be routine and short term or catastrophic and long term. The procurement risk differs from disruption risk since it refers to unanticipated increases in acquisition costs resulting from fluctuating exchange rates or supplier price increases (Chopra and Sodhi, 2004). This thesis will look at disruption risk in the aerospace industry. Reviewing the literature on supply chain risk, (Chopra and Sodhi, 2004, Tomlin, 2006, Mohd Nishat et al., 2006) identifies that there are a number of tactics that can be employed to reduce disruption risk in a supply chain. These include:

- Increasing inventory
- Increasing capacity
- Acquiring redundant suppliers
- Increasing/improving communication

These solutions have cost implications but increasing and improving communication has potentially the least cost implications. Increasing capacity and acquiring redundant supplier has large capital implications. Increasing inventory means tying up capital or holding material in the warehouse. Increasing/improving communications can be done during the normal day to day communications with suppliers. The improvement of communication can be the development of closer relationships with suppliers, the increase in frequency of communication with suppliers, and the building of new relationships with individuals in the supplier organisations. The practical cost of doing this would have the least cost implications from the list above. Reducing supply chain risk through improving the flow of information is an intuitively attractive proposition. Social networks can be used to carry information; this thesis therefore postulates that individual's social networks could be harnessed to do this more effectively.

A retrospective case study reviewed by the researcher in the aerospace industry found that when a company went bankrupt in the supply network of the OEM, the OEM was first alerted of the imminent bankruptcy through the social network of one of its employees. Thus, it was the dyadic relationship between two actors in the supply network which allowed the OEM to identify the risk of disruption in the supply network through more rapid and effective information flow.

The explicit mapping, analysis and shaping of individuals' social networks have been undertaken with success in a new product development context in the aerospace

industry (Brookes et al., 2007). The experience of using these social network mapping and analysis techniques could be used in a supply chain context to capture relational ties between individual node actors in different supply chain organisations. These interactions would not be confined to adjacent supply chain tiers but may exist along the entire supply chain thus giving much greater advance warning of potential risk. By identifying potentially productive relational ties between actors, conduits of rapid supply chain information flows could be identified. Where no such relational ties exist, their development could be encouraged. Thus, organisations could explicitly create and maintain social networks to propagate information flow in a way to substantially mitigate their exposure to supply chain risk.

1.1 Summary of Project

The initial aim of the studentship was in regard to “Robust Operational Network Design”

1.1.1 The Aim of the Project for the Academic Collaborator

The aim of the project for the academic collaborator is to explore the issues surrounding the identification of vulnerabilities through robust network design. The aim of the investigation for the industrial collaborator is to develop a tool that enables the identification of vulnerabilities in an organisation’s operational network and assists in determining interventions to improve network robustness.

Organisations increasingly use an extended operational network as the most effective structure to fulfil their strategic objectives. These networks are becoming increasingly complex and hence increasingly subject to vulnerability and risk. These

issues are particularly pertinent when organisations are considering making their networks even more complex through outsourcing, restructuring or pursuing new business development opportunities. The ability to diagnose network vulnerabilities and build robust operational networks will become a key business competence.

This project will draw together theoretical models and practitioner learning from the disparate fields of supply chain management, risk identification, risk assessment and the application of the social network perspective. It will use this body of work to create network mapping, diagnosis and construction techniques that will reduce vulnerabilities and increase robustness in operational networks.

The deliverables from the project were originally to:

Develop a prototype tool for supply chain risk management

Guidance on the use of the tool

Documented case study applications of the prototype tool in the industrial collaborators' organisation (OEM) and in other organisations identified by the industrial collaborator

However when the OEM merged with another company, these deliverables were modified, with the new supply chain manager in the OEMs merged company bringing in his own tool for supply chain risk management, DNBi, making the tool developed from this research no longer applicable. Therefore the research then focused on using the information gathered from the exploratory case studies at the OEM to develop and test research propositions using a focus group methodology. The new deliverables thus being:

Exploratory study of supply chain risk in OEM

Exploratory study of risk perceptions in OEM's suppliers

Discuss Findings via Focus Groups in the OEM and an Expert Setting (Aston University)

1.2 Background of OEM and Aerospace Sector

Despite the downturn in civil passenger travel that followed the events of 11 September 2001, continued uncertainty in the Middle East and the SARS crisis in Asia, the UK aerospace industry (UKAI) remains one of the most successful sectors of UK manufacturing. In 2003, the UKAI accounted for 0.6 percent of UK gross value added (GVA) and four percent of value added by the UK's manufacturing industry as a whole. The first UK recession may be officially over, but almost every sector is still feeling the effects of the downturn. Despite the adverse economic conditions that prevailed over the two years to 2010, total aerospace sales in 2010 rose to £23.1 billion, up by 2.1 per cent on 2009, which is a new record for the eighth year running.

The UKAI is also one of the UK's major export sectors, generating a trade surplus of just over £2.5 billion in 2003, compared with manufacturing overall, which had a trade deficit. The UKAI provides direct and indirect employment in the UK for around 255,000 people in 2003.

Although productivity levels in the UKAI are generally higher than the UK average, they remain disappointing when compared to the industry's main international competitors. However, there are signs that UKAI productivity growth is beginning to outpace these competitors. Evidence suggests that there will be a further challenge for the UKAI as competition from emerging economies is growing.

The UK aerospace industry (UKAI) is one of the most successful sectors of UK manufacturing. Its importance and achievements can be illustrated as follows:

- In 2003, the UKAI had a turnover of just over £17 billion and captured ten percent of the world market for aerospace products;
- The UKAI accounted for just over four percent of UK manufactured output and directly contributed just over £5.5 billion to UK gross value added (GVA)¹ in 2002, a similar level to the pharmaceutical industry;
- There has been a consistently positive aerospace trade balance in the past two decades. In 2003 it was £2.6 billion (close to its long run average of £2.8 billion);
- In 2003, the UKAI directly employed just under 122,000 people, 0.4 percent of total UK employment, and three percent of total manufacturing employment. An additional 150,000 people have been estimated to be indirectly employed by the industry;
- UKAI productivity was £54,000 per head in 2001, 50 percent higher than the UK average and 35 percent higher than for manufacturing as a whole; and
- The aerospace industry invested just over £2 billion in UK R&D in 2003, second only to the pharmaceutical sector. Three aerospace companies featured among the top ten UK R&D investors.

(House of Commons Trade and Industry Committee. The UK
Aerospace Industry Fifteenth Report of Session 2004–05).

The parent company of the OEM designs and makes high performance components and sub-systems for the aerospace and defence markets. The company manufactures wheels, brakes, brake control systems, aerospace valves, ice protection, heat management components and as well as thermal management. It also manufactures polymers and composites, environmental control systems and counter measure launch and recovery systems. The companies other capabilities include providing training systems, combat support systems, avionics, automotive and industrial control electronics. The company serves various sectors like

aerospace and defence, oil and gas, medical, mainstream industrial, test engineering and transportation sectors offering high-performance sensing and condition-monitoring solutions for rotating machinery as well as air and land-based machinery. The parent company has around 36 operating companies through which it operates in the US, Spain, Switzerland, France, Singapore and China.

The OEM has its headquarters in Coventry, UK. The company provides a host of wheel and braking products and services to the aerospace industry and it has a history in the marketplace stretching back almost 100 years. The company has an annual turnover of over \$150 million and employs over 700 people worldwide.

The OEM has undergone a merger with another aerospace company. Both operate under the new name of the combined businesses.

The OEMs name was created following the parent group's acquisition of another aerospace company in July 2007. This was part of a wider acquisition of another company, a specialist producer of fuel bladders, fuel cells and ice-guards. The braking systems portion of the acquisition is being integrated with the established parent group. The OEM is part of the parent group, an international group operating in North America, Europe and Asia. Known for its specialist extreme environment engineering, it is a world leader in aerospace equipment, sensing systems and defence training and combat support systems.

Since January 2008, the OEM has been the trade name of the businesses supplying aircraft wheels and brakes. The OEM is one of the leading aircraft wheels and brakes suppliers in the world, and has facilities on both sides of the Atlantic, as well as in Europe and Asia. The OEM provides aircraft braking systems to a diverse group of customers, which include, but are not limited to, airline operators, aircraft

constructors, private aircraft owners and charter operators, governments and military operations, distributors and repair stations. The vision of the OEM is to be the braking systems supplier of choice and employer of choice in the industry.

Over 160 aircraft platforms use the OEMs wheels and brakes. They supply the wheels and brakes to over 700 new aircraft in 2008. Approximately 31,000 aircraft take off and land with the OEMs wheels and brakes. The wheels and brakes make over 15 million landings every year.

The OEMs carbon products have accumulated in excess of 20-years in-service experience on over 45 aircraft platforms. Proven in all operating environments on military and commercial aircraft, from small general aviation aircraft to large passenger jets, the carbon brake products are amongst the best in the world.

The OEMs products are specified on over 100 aircraft platforms currently in operation, with a fleet size in excess of 20,000 aircraft. The combined experience dates back to the invention of multi-disc steel aircraft brakes in the 1930's and includes the very latest sintered pad technology currently used on modern production commercial and military aircraft such as the Embraer Phenom 100 and Lockheed-Martin C130J.

The OEM pioneered brake control systems on aircraft over 50 years ago and have since been investing in the development of market leading products such as state-of-the-art brake-by-wire systems (BBWS) and tyre pressure indicating systems (TPIS). The OEM are one of only a few companies in the world that can provide complete integrated braking systems that include the wheels, brakes and brake control element; and have successfully demonstrated this capability on over 50 aircraft platforms currently in operation today.

1.3 Methodology

Chapter 3 summarises the philosophical underpinnings of the thesis and goes on to argue that the methodology should consist of a case study which begins with an exploratory case investigation within the aerospace OEM. The literature review allowed the development of research themes that were used in the exploratory case consisting of 13 semi-structured interviews at the OEM and two interviews in two of the OEM's suppliers. The analysis of the interviews allowed the propositions of the thesis to be developed. These propositions will be discussed in the following section. The propositions were then discussed through four focus groups, consisting of two groups at the OEM, followed by two academic groups that were conducted with members of the Operations and Information Management Group at Aston University. Both the interviews and the focus groups were analysed using the coding application Nvivo.

1.4 Research Propositions

The propositions that are developed in this thesis are: (explored further in chapter 5)

- By improving information flows, through the use of social networks, we can identify supply chain disruption risk.
- The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

The exploratory case study (explored further in chapter 4) within the OEM found that social networks are currently being used to gather information to identify supply

chain disruption risk. This process is tacit and not formalised. This thesis will explore whether by improving these information flows, the organisation can identify supply chain disruption risk more effectively.

Supply chain risk information management was identified as an area of improvement in the exploratory case study. The triggers to identify risk were received into different departments of the organisation. The management of this information needs to be further explored. An emerging theme from the exploratory case study when analysing the triggers to identify risk, was that information can be pushed or pulled into the organisation. The push and pull concept is used to explore the management of supply chain disruption risk information in the organisation. The push concept refers to when a supplier of information takes the initiative to deliver the information to the individual in the OEM. The Pull concept refers to when an individual in the OEM takes the initiative to get the information themselves from a supplier for example (Herman, 2010). Another emerging theme coming from the exploratory case study, and interviews with suppliers was that risk perceptions varied between the OEM and its suppliers.

1.5 Contribution

The literature highlights good communication and relationship management are important factors in reducing supply chain risk (Mitchell, 1995; Condon, 2007, Juttner, 2005; Juttner, et al, 2003; Khan and Burnes, 2007). However, little research has been done on examining the information flows that lead to the identification of disruption risk. This point is particularly important since the literature suggests that most strategies to identify and mitigate supply chain risk are expensive, i.e. to reduce risk one can build buffers in all interfaces to other companies, but doing so is

expensive in the short run (Sorenson, 2005). “The better sharing of information is the key. Information is always the cheaper thing to share, rather than having spare capacity or inventory.” (Condon, 2007, page 55). Mohd Nishat, et al. (2006) stress that information sharing, communication and coordination among all elements of the supply chain are essential to its success. Thus the contribution to research that this thesis aims at is supply chain disruption risk can be identified with the aid of information flows and analysing individual’s social networks.

Both the propositions of this thesis have provenance through the findings of the exploratory interviews and are not explored in any depth in current research or published literature. The methodology (further explored in chapter 3) was thus to use the literature review to lead to exploratory themes which were then used to aid the exploratory case study in the OEM. This study led to the research propositions, which were then further explored through focus group analysis in the OEM and an academic setting.

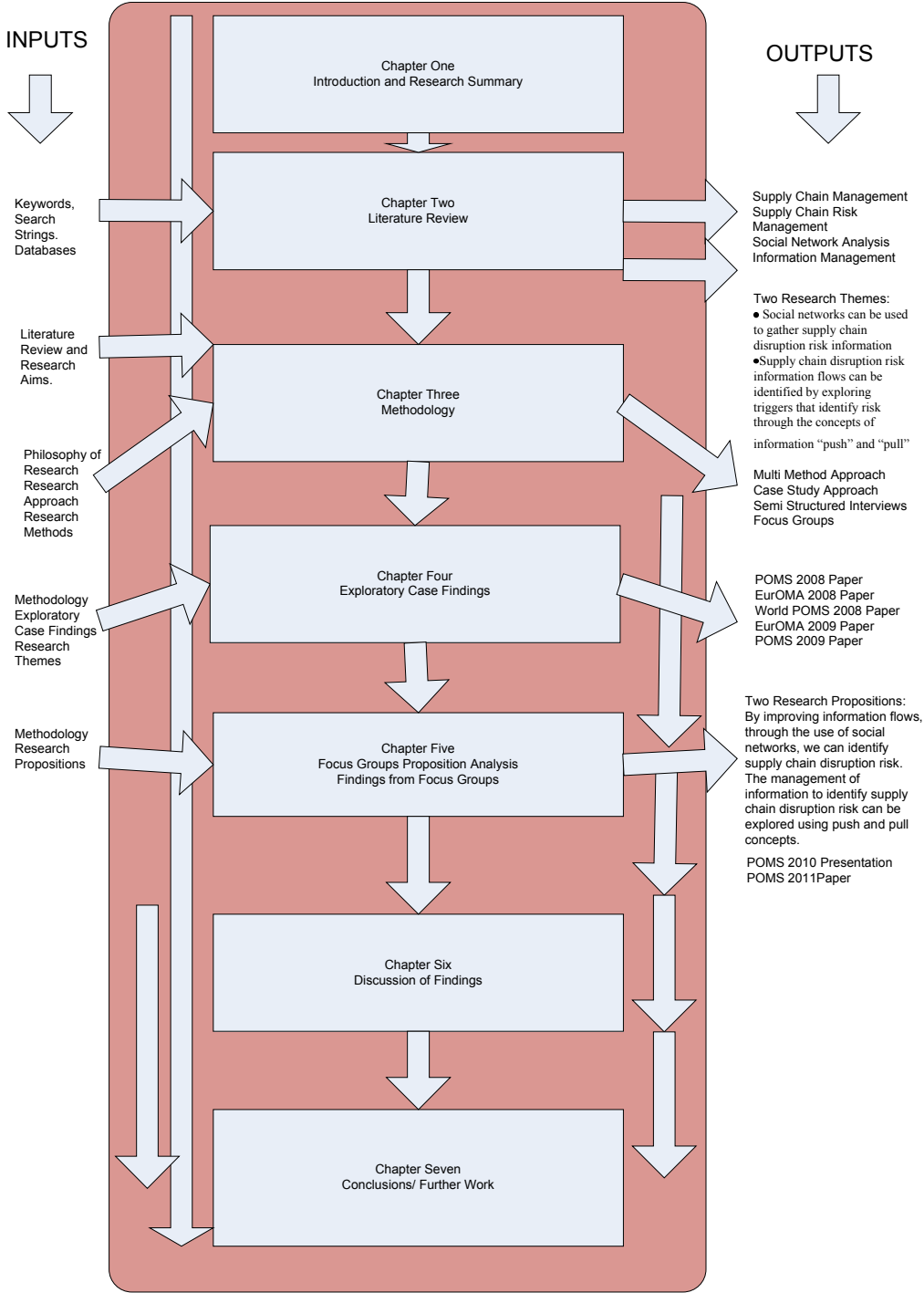
The main research question that will be explored in this thesis is therefore: can social networks and information management analysis be used to improve the ways that an organisation identifies supply chain disruption risk?

1.6 Overview of Chapters

The literature reviews of key papers are explored in chapter 2. This was followed by the study of the exploratory aims or themes that have been identified from the literature. These issues are then translated into a research methodology, where case studies, including interviews, and focus group methodologies are explored in chapter 3. Chapter 4 explores the exploratory case study in the OEM. The findings

about the propositions are explored in chapter 5. Discussions around the findings from the exploratory case study and focus groups are found in chapter 6. Chapter 7 looks at conclusions and the direction of any further work. A summary of the chapters in a diagrammatic form can be seen in figure 1.1

Figure 1.1: Chapter Summary



1.7 Chapter Summary

This chapter has reviewed the background to the research, in particular in respect of the conceptualisation of the research, from the OEMs retrospective case study on supply chain disruption. A brief outline of the literature surrounding supply chain risk and social network analysis has been explored. The following chapter will examine the literature in more detail. The methodology of the thesis is qualitative and will be analysed in later chapters. It was seen as the most appropriate method to research the initial aim of the research which was how to identify disruption risk in an aerospace supply chain through the examination of information flows and through social networks. The examination of information flows will be explored in terms of push and pull information management.

The contribution of this thesis is the development of two propositions which can be applied by practitioners in the OEM organisation to improve the identification of supply chain disruption risk. These propositions have provenance in the exploratory case study conducted in the OEM and also in the literature review. The propositions are unique in that research was not found which used the application of the social network perspective and information flows in terms of push and pull, to examine supply chain disruption risks.

Chapter Two - Literature Review

2.0 Introduction

This chapter will explain the method in which the literature review was conducted and then the literature is reviewed in sections relating to the main aim of this thesis mentioned in the previous chapter. This aim being social networks and information management can help to identify supply chain disruption risk. The sections within this chapter look at supply chains and supply chain management, then supply chain risk management is explored. Social network literature is then reviewed, followed by knowledge and information management literature in relation to information flows.

2.1 Analysis of Core Literature

The key articles were selected from all the relevant articles found through the literature review. This was done through a refinement of searches using key strings such as information and risk, disruption risk and supply chain, and supply chain risk management, for example. The key strings were used to group the literature and summarise the findings further. The articles were then read and will be summarised and reviewed in the following sections. The section on risk and supply chains, 2.4, will be organised chronologically to show the changes over time of research on supply chain risk. It will be seen that the literature has more and more empirical research in supply chain risk over time.

2.2 Supply Chain Management

Oliver and Webber (1982) first coined the phrase supply chain management (SCM). They explained the difference between SCM and logistics by the holistic view and strategic nature of SCM (Oliver and Webber, 1982). Harland (1996) goes on to divide the definitions of SCM into: management of supply relationships, management of inter-business chains, and management of inter-business networks. Four main uses of the term SCM are then proposed (Harland, 1996):

1. The internal supply chain from inbound to out bound ends of the business.
2. The management of dyadic relationships between immediate suppliers.
3. The management of a chain of businesses including a supplier, a supplier's supplier and so on.
4. The management of a network of inter-connected businesses involved in the provision of product and service packages required by end customers.

A key characteristic of SCM is the coordination of activities between interdependent organisations and thus can be defined as “the management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place, at less cost to the supply chain as a whole” (Christopher, 1998, page 5).

Every company is linked to other companies, forming supply chains. A single disruption to one entity in the supply chain affects the whole chain. Adapting to change involves risk, but continuing in traditional ways is also risky (Pankaj Raj et al., 2004). Despite increasing awareness among practitioners, the concepts of supply chain vulnerability and its managerial counterpart supply chain risk management are still being researched (Juttner and Zeigbehnan, 2009). Supply

chain risk management (SCRM) is increasingly receiving attention from both academics and practitioners. However, the concept of SCRM and understanding of SCRM is patchy, both in terms of its key issues and its implementation (Jüttner, 2005). Sodhi et al. (2011) agree with this and suggest that there are three “gaps” pertinent to future research in SCRM:

1. No clear consensus on the definition of SCRM;
2. A lack of commensurate research on response to supply chain risk incidents;
3. A shortage of empirical research in the area of SCRM.

Khan and Burnes (2007) go on to argue that in the area of SCM, risk is less understood than in other disciplines and less developed. They suggest the use of case studies to investigate:

- How companies manage supply chain risk
- What processes and techniques companies use to identify and analyse risk in their supply chains

Research into theory and practice in the above, can allow future research to devise robust and well grounded models of supply chain risk management, which incorporates risk management tools and techniques from other disciplines of research (Khan and Burnes, 2007). This suggests that future research can develop a tool to identify risk, as proposed by this thesis, and use other disciplines such as social network analysis and information flows analysis to accomplish this aim.

Hendricks and Singhal (2003) argue that the failure to manage supply chain risks effectively can be costly. They found that on average major supply chain disruptions

can reduce the stock market value of a company by 10 per cent (Hendricks and Singhal, 2003).

Supply risk is defined by Zsidisin (2003), from a review of the literature, as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety. Chopra and Sodhi (2004) in their theoretical paper go on to argue that there are nine categories of risk: Disruptions, Delays, Systems, Forecast, Intellectual Property, Procurement, Receivables, Inventory, and Capacity. This disruption can be mundane and short term or catastrophic and long term (Chopra and Sodhi, 2004). Supply chain risks are anything that may disrupt or impede the information, material or product flows from original suppliers to the delivery of the final product to the ultimate end-user (Peck, 2006). This category of risk and definition of supply chain risk disruptions will be the focus of this thesis since it most closely relates to the original research aim of this thesis, in terms of supply chain risk and disruptions. The main aim for this thesis is therefore focused on disruption risks and to some extent delay risks.

2.3 Risk, Resilience and Vulnerability

Supply Chain Risk Management (SCRM) is described as “the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole” (Juttner et al., 2003, page 201.). The essence of resilience is the containment of disruptions and how an organisation recovers from them (Sheffi, 2005).

Figure 2.1: The Relationship Between Supply Chain Resilience, Supply Chain Risk Management and Supply Chain Vulnerability



Source: Supply chain resilience in the global financial crisis: an empirical study
Juttner and Maklan (2011).

Christopher and Peck (2004) defined supply chain resilience as the ability of the supply chain to return to its original state or move to a new, more desirable state after being disturbed. Figure 2.1 summarises the relationship between supply chain risk management, supply chain resilience and supply chain vulnerability from a literature review of the relationships by Juttner and Maklan (2011). Depending on the primary target of the specific risk strategy or action, either the supply chain resilience, the supply chain vulnerability or the supply chain resilience and supply chain vulnerability should be positively affected by supply chain risk management. Thus as depicted in figure 2.1 one aim of supply chain risk management is to reduce supply chain vulnerability (-) and increase supply chain resilience (+). Supply chain resilience also aims to reduce (-) supply chain vulnerability.

Sheffi (2005) examined the ways in which companies can recover from high-impact disruptions and focused on actions to lower vulnerability and increase resilience. These include: 1) reducing likelihood of disruptions through monitoring and detecting weakest signals, demand responsive supply chains, supply-chain wide collaboration, redundancy; 2) operational flexibility through standardisation of parts facilitating interchangeability, postponement or mass customisation strategy to respond to unpredictable demand changes, customer and supplier relation management and multiple sourcing. These weakest signals can also be seen as triggers of risk, as argued by Harland et al. (2003), who go on to say that the likelihood of an event occurring depends partly on the extent of the exposure to risk and partly on the likelihood of a trigger that will realise the risk. This leads to one of the research questions in the exploratory case study which will be analysed in chapter 4, since the literature mentions the triggers but no explanation of what the triggers may be or what the weakest signals may be.

Tang (2006) viewed resilience as a competitive advantage for supply chains and suggested developing robust strategies for mitigating supply chain disruption effects from supply and demand management perspectives. He suggests postponement, strategic stock investment, flexible supply base, economic supply incentives, multi-modal flexible transportation for improving supply management and dynamic pricing, dynamic assortment planning, silent product rollover for improving demand management.

Supply chain risk management will be the focus of this thesis since it is the overall definition of risk, and encompasses how to reduce the vulnerability and increase resilience (Sheffi, 2005) through the mitigation of risk. The themes of the research will therefore look in particular at how disruption risk can be identified through the use of social networks and information flows analysis.

2.4 Risk and Supply Chains

Mitchell (1995) suggests that risk reducers include; choosing a leading company in the field, using an approved list of suppliers, multiple sourcing, visiting supplier operations and establishing good communications with suppliers (Mitchell, 1995). This view is supported by Condon, (2007) who argues that mitigation strategies, such as having spare capacity and alternative suppliers are expensive; the better sharing of information is the key. Information is always the cheaper thing to share, rather than having spare capacity or inventory (Condon, 2007). The argument against this view is that if a supplier went bankrupt, the OEM will still have to find an alternative supplier at the expense of the OEM in terms of time finding suppliers as well as the practical cost of securing new contracts. Condon's view that information sharing is the cheaper thing to share can be argued to be right in theory but can be criticised in practice when securing new suppliers which would be equally as expensive as keeping alternative suppliers. However, Condon's view is also supported by Sorenson (2005), in a literature review of risk and uncertainty in SCM, Sorenson found one way of minimising the vulnerability of the supply chain is to build buffers in all interfaces to other companies, but doing so is expensive in the short run, and costs the company dearly on lack of information in the long run. Sorenson goes on to argue that further research into frameworks for identifying risk sources from a SCM perspective might be a first step in introducing risk management into the design of supply chains (Sorensen, 2005). These risk sources can be seen as triggers to risk. Thus they are important to identify and capture as early as possible to aid in the mitigation of those risks. The level of an in-stock inventory, production throughput, capacity utilization and delivery lead times are some of the triggers that can be used to identify an abnormal situation that may involve a potential risk

(Giannakis, et al., 2011), however few studies have investigated the triggers in an empirical methodology.

The aspects of improving communication is touched upon by Zsidisin, et al. (2000), they suggest that purchasing professionals can reduce the impact of risk by implementing process improvements and appropriate buffering strategies. Process improvement focuses on building strategic alliances and developing new suppliers, improving communications, and collaborating to achieve a common goal. Buffer strategy focuses on maintaining inventories in the supply chain at appropriate levels and locations. This is a precaution against any unforeseen risks, which cannot be eliminated or reduced by implementing process improvement strategies (Zsidisin, et al., 2000). Collaborative relationships among supply chain partners are seen as a variable that can impact risk by Mohd Nishat, et al. (2006). They argue that in order to manage risk effectively in a supply chain, organizations are moving to adopt closer relationships with key suppliers. Improved communications can be seen as the underpinning of such collaborations.

Juttner, et al. (2003) argue in their empirical paper that whilst risk has always been present in the process of reconciling supply with demand, there are a number of factors that have emerged in the last decade or so, which might be considered to have increased the level of risk. These include: (1) a focus on efficiency rather than effectiveness; (2) the globalisation of supply chains; (3) focused factories and centralised distribution; (4) the trend to outsourcing; and (5) the reduction of the supplier base. One of the ways to mitigate risk from a supply chain perspective, is to focus on joint agreements among organisations in the supply chain to improve supply chain visibility and understanding, to share information on exposures to specific risk sources and, finally, to prepare joint business continuity plans (Juttner, et al., 2003). The sharing of information between supplier tiers has again been

highlighted as important and thus the notion of social networks and information management can be seen as one aspect to identify risk from a supply chain perspective.

Chopra and Sodhi (2004) begin their theoretical paper by outlining how a fire in a semi-conductors factory allowed Nokia to use responsiveness and communication to build a strategy that allowed them to suffer little during the crisis. They go on to state that the big challenge for managers is to mitigate risk by intelligently positioning and sizing supply chain reserves without decreasing profits. They go on to argue that there are a number of mitigation approaches and specific tailored strategies that can be used to mitigate risk, these are:

1. Increase capacity
2. Acquire redundant suppliers
3. Increase responsiveness
4. Increase inventory
5. Increase flexibility
6. Pool or aggregate demand
7. Increase capability

Increasing capacity, acquiring redundant suppliers and increasing inventory all have cost implications. Whereas increasing responsiveness, flexibility and capability do not have such cost implications.

Bales et al.'s (2004) empirical research in the aerospace industry finds that outsourcing periphery activities has altered the shape of the supply chain. This is a very important issue that can be further researched. The research found that risk is passed down the supply chain now that material is no longer freely issued by the

OEMs to the sub contractors. Outsourcing has altered the supply chain structure and decentralised the flow of information. OEMs have transferred risk down the supply chain, and have lost direct control of the information flows at the basic supply and demand level (Bales et al., 2004). The notion that risk can be passed down the supply chain and that close information management needs to be maintained when outsourcing activities suggests that information management between tiers of suppliers is very important to identify and therefore mitigate risk. This notion will be explored in the exploratory case study in the OEM.

Martin and Hau's (2004) theoretical paper suggests that one key element in any strategy designed to mitigate supply chain risk is improved "end-to-end" visibility. It is argued that supply chain "confidence" will increase in proportion to the quality of supply chain information (Martin and Hau, 2004). It was highlighted that supply chain management and networks are an important area of study by Mika and Jukka, (2006). Furthermore, there are many benefits associated with networking, but also possibly problems and risks.

Finch (2004) look at a secondary analysis of literature supplemented by case studies to determine if large companies increase their exposure to risk by having small and medium sized enterprises (SMEs) as partners in business critical positions in the supply chain. Findings shows that large companies' exposure to risk appears to increase by inter organisational networking, and were further increased by having SMEs as partners in the supply chain. Mohd Nishat et al. (2006) go on to argue that risk susceptibility is dependent on other constituents of your supply chain. They go on to stress that information sharing and communication and coordination among all elements of the supply chain are essential to its success (Mohd Nishat et al., 2006).

In the empirical paper by Hallikas et al. (2004) risk management in supplier networks is dealt with. The primary aim is to illustrate challenges that network co-operation brings to risk management. The paper outlines the general structure of the risk management process and presents methods for risk management in a complex network environment. The results indicate that risk management is an important development target in the studied supplier networks. Another finding was when the dependency between companies increases, they become more exposed to the risks of other companies. Thus some form of supply chain risk management is required that encompasses the whole supply chain network.

Pankaj Raj et al. (2004) in their paper present a generic prescriptive methodology for mitigating risks in the aerospace supply chain. A case study is then presented on how the methodology can be applied. The purpose of risk analysis is to develop a structured way of defining, identifying, assessing, and mitigating the risks. The paper uses interviews and focus groups to identify and assess the risks. Quantitative methods are used to assess the risks also, but the paper does not elaborate on the methods used or the results of the analysis. The methodology provides a mechanism to minimise conflicting objectives. A hypothetical case study is then presented on how the methodology can be applied. The paper however does not use any empirical evidence to back its findings, so future research could do this in a more practical setting. The major factors contributing to supply chain risk are lack of trust, withholding information, dependence on outsourcing and standardized contracts. Risk analysis is a practice with methods and tools for identifying risks in a process. One of the most important factors affecting the entire process of supply chain management is the trust among the trading partners. A key factor affecting trust is the nature of the people participating in the business. The entire supply chain operation will be constrained if people can not be trusted to do their jobs properly.

Normann and Jansson (2004) describe how Ericsson, after a fire at a sub-supplier, with a huge impact on Ericsson, has implemented a new organisation, and new processes and tools for SCRM. The approach described tries to analyse, assess and manage risk sources along the supply chain. Risk analysis/identification is an important stage in the risk management process. Consequently, by identifying a risk, decision-makers become aware of events that may cause disturbances. To assess supply chain risk exposures, the company must identify not only direct risks to its operations, but also the potential causes or sources of those risks at every significant link along the supply chain. Since only limited empirical research on how companies deal with supply chain risk management has been found, an explorative approach has been chosen. In this study, a single case is used.

Jukka et al. (2004) outline the general structure of the risk management process and presents methods for risk management in a complex network environment. The results indicate that risk management is an important development target in the studied supplier networks. When the dependency between companies increases, they become more exposed to the risks of other companies. The presented processes facilitate understanding and managing of uncertainties and risks in supplier networks. Empirical evidence is offered on the basis of case studies. A typical risk management process of an enterprise consists of

- Risk identification,
- Risk assessment,
- Decision and implementation of risk management actions,
- Risk monitoring.

It is argued that the risk management process in a network environment has the same phases. Risk identification is seen as an important aspect of the risk

management process, and will be used in this thesis to explore the propositions in chapter 5.

Jukka et al. (2004) argue that risk identification is a fundamental phase in the risk management practice. By identifying the risks, a decision-maker or a group of decision-makers become conscious about events or phenomena that cause uncertainty. The main focus of risk identification is to recognise future uncertainties to be able to manage these scenarios proactively. Risk assessment and prioritisation are needed to be able to choose suitable management actions for the identified risk factors according to the situation at both company and network level. The generally used strategies for risk management include:

- Risk transfer,
- Risk taking,
- Risk elimination,
- Risk reduction,
- Further analysis of individual risks.

In a network environment, risks can be managed generally by developing a common network strategy, best practice modes of action and contract policies. Inter organisational information sharing and knowledge transfer cause a great deal of uncertainty and risk. The development of information and knowledge systems is therefore a great challenge and also a potential means to manage risks.

Christopher and Peck (2004) suggest that better management and control of internal processes together with more open information flows within and between organisations can do much to help the SCRM process. Their work is empirically based and draws on insights from a number of important industries including food

retailing, oil and petrochemicals, pharmaceutical, packaging, electronics, transport services and the distribution of automotive spares. It also includes input from private and public sector organisations involved in the provision of health care and in defence. In particular it focuses on the development of a managerial agenda for the identification and management of supply chain risk, with recommendations to improve the resilience of supply chains. From the evidence contained in this study there is limited but an expanding pool of work which is needed for a structured approach to the management of supply chain risk.

Kleindorfer and Saad (2005) suggest that there are two broad categories of risk affecting supply chain design and management: (1) risks arising from the problems of coordinating supply and demand, and (2) risks arising from disruptions to normal activities. Their paper is concerned with the second category of risks, which may arise from natural disasters, from strikes and economic disruptions, and from acts of purposeful agents, including terrorism. Kleindorfer and Saad (2005) categorise risks into two types: (1) risks related to supply and demand coordination and uncertainty, and (2) disruption risks that are caused by such events as natural disasters, terrorism and labour strikes. Kleindorfer and Saad (2005) outline a list of 10 principles developed from the industrial risk management and supply chain literatures. Again, these principles are subsumed within the network of constructs considered in this research, and several of them validated by the findings. The research finding that internal integration is an important precursor to both external integration with key customers and key suppliers. One principle advocated by Kleindorfer and Saad (2005) refers to the need for early warning systems. The presence of early warning systems can be related to active environmental scanning emphasized by the market orientation construct. These early warning systems suggest that the risk identification phase of risk management is an important aspect of SCRM.

Cruz et al. (2005) develop a supply chain network model in which both physical and electronic transactions are allowed and in which supply side risk as well as demand side risk are included in the formulation. The model consists of three tiers of decision-makers: the manufacturers, the distributors, and the retailers, with the demands associated with the retail outlets being random. Furthermore, the management of supply chain networks must consider the complexity of interactions among the various decision-makers, coupled with appropriate decision-making criteria. Future research will include empirical work as well as extensions of the model to global supply chain networks.

Jüttner, (2005) in an empirical paper argues that discussion has focused on risk and uncertainty and disruption in single organisations. Applying the knowledge gained from a single organisation perspective to a supply chain context is limited because it does not reflect a supply chain orientation (Jüttner, 2005). Any approach to managing risks from a supply chain perspective must have a broader scope. Jüttner (2005) argues that risk in the supply chain centres around the disruption of flows between organisations. These flows relate to information, materials, products, and money. They are not interdependent of each other but are clearly connected. A key feature of supply chain risk is that, by definition, it extends beyond the boundaries of the single firm and moreover, the boundary spanning flows can become a source of supply risks. Again this reinforces the notion that the information flows between supplier tiers need to be identified and analysed.

Jüttner (2005) found a list of nine process based methods or tools, from a literature review, that help identify and assess supply chain risks from a supply chain context.

The nine are:

1. Assessing the importance of your business to your customers' business
2. Critical path analysis
3. Supply chain mapping
4. Assessing the importance of your business to your suppliers' business
5. Brain storming
6. Process mapping
7. Risk likelihood/impact analysis
8. Scenario planning
9. Six sigma method

The findings of this paper (Juttner, 2005) show, that less formalised processes and tools, are more popular than the formalised tools. This is an important finding in relation to this thesis since social networks and information and relationship management relate to the original aim of the thesis, and are a less formalised process to identify and therefore mitigate supply chain risk. Khan and Burnes (2007) findings show that a number of tools for quantifying and managing risk have been developed. These include FMEA (failure mode effect analysis), CBA (cost benefit analysis), RBA (risk benefit analysis). Khan and Burnes (2007) argue that these tools have been criticised for removing human judgement from decision making by disguising underlying assumptions with mathematical formulae. They go on to quote Adams (1995) who argues that rarely are risk decisions made with information that can be reduced to quantifiable probabilities, yet somehow decisions get made. The argument is that risk cannot be broken down into probabilities and requires human judgement to analyse risk and mitigate it. This is an important notion in respect of the themes to be proposed for this thesis and to be discussed later on in this chapter.

When the Supply Chain Operational Reference (SCOR) model literature was analysed, Kasi (2005) found that SCOR was strong on technical dimensions such as

modelling process and techniques but weak on the social dimensions (Kasi, 2005). Burgess and Singh (2006) in their empirical paper go on to state that current methodologies for analysing supply chains, such as SCOR, are not sufficiently comprehensive, particularly when understanding the complex political and social aspects of a supply chain. These findings coupled with Christopher and Peck (2004) who state that the implications of resilience in a supply chain extends beyond process redesign to fundamental decisions on sourcing and the establishment of more collaborative supply chain relations (Christopher and Peck, 2004). These findings suggest a more comprehensive model that incorporates the social aspects of collaboration in a complex supply chain could be developed in future research.

With the emergence of the concepts of lean, agile and leagile paradigms for supply chains, organisations have little idea as to which model suits them based on the their supply chain's ability to counter risks and take on the challenges of the fast changing customer preferences (Mohd Nishat, et al., 2006). So the major objectives of this paper can be stated as:

. To develop a model that maps traditional, lean, agile and leagile supply chains on customer sensitivity and risk alleviation competency dimensions.

. To evaluate the suggested model for case supply chains by quantifying risk alleviation competency and customer sensitivity dimensions.

Four major components of risk management are then identified:

1. Risk identification;
2. Risk analysis;
3. Risk-reducing measures;
4. Risk monitoring.

Risk identification and risk monitoring are important aspect of SCRM. This thesis will use these aspects to explore the research propositions in chapter 5.

Wu, et al. (2006) present four arguments within their research: (1) inbound supply risk factors are identified through both an extensive academic literature review on supply risk literature review as well as a series of industry interviews; (2) from these factors, a hierarchical risk factor classification structure is created; (3) an analytical hierarchy processing (AHP) method with enhanced consistency to rank risk factor for suppliers is created; and (4) a prototype computer implementation system is developed and tested on an industry example. The inbound risk factors are a part of the risk identification process, these need to be explored further, and this thesis will use risk triggers and behavioural indicators to assess these.

Mohd Nishat, et al. (2006) present an approach to effective supply chain risk mitigation by understanding the dynamics between various enablers that help to mitigate risk in a supply chain. The paper lists several enablers for supply chain risk mitigation. These include information sharing, supply chain agility, trust, collaborative relationships all of which form part of the network of constructs considered in this study. Their assertion that collaborative relationships, information sharing and trust among supply chain partners are major drivers of risk mitigation has been generally validated, even though trust among supply chain partners was not explicitly studied in this research. The methodology used is that of interpretive structural modelling and the research presents a hierarchy-based model and the mutual relationships among the enablers of risk mitigation. But this model has not been statistically validated. Structural equation modelling (SEM), also referred to as linear structural relationship approach, has the capability of testing the validity of such hypothetical

models. Thus, this approach can be applied in the future research to test the validity of this model.

Sodhi and Lee (2007) present findings from a single case study of Samsung electronics UK. Their article seeks to provide a starting point for understanding supply chain risk in this industry through examples from this industry as well as from related ones like computers and mobile phones. Samsung mitigates supply chain risks by keeping inventories low, keeping capacity flexible, having redundant suppliers for a bulk of its non-core components, and using information technology to keep its supply chain from the plant to the end consumer responsive and informed. Thus, Samsung minimises the use of expensive inventory and excess capacity. Instead, Samsung opts for a responsive flexible capacity through multi-platform and plants integrated with those of their core-component suppliers. Managing these risks is difficult. Mitigating one risk may lead to increasing the possibility or the impact of another. Taking actions to make the supply chain more efficient may end up increasing the risk of any disruption in the supply chain. They argue that there is much modeling and empirical work to be explored in the area of supply chain risk management.

A risk can be measured through the presentation of a global supply chain as a dynamic system in time or in frequency domain, Bogataj and Bogataj (2007) present the use of the frequency space to measure and control risk in a supply chain. The model of risk measurement is based on the previous studies (Grubbström, 1967, Bogataj and Bogataj, 2004) of Input–Output Analysis and Laplace transforms of a supply chain model which, in turn, is based on the ideas of stochastic modelling. Mathematical formulae are used to measure supply chain risk and vulnerability. Risk identification hasn't been explored in the paper neither has risk mitigation.

Braunsscheidel and Suresh (2009) present a hypothetical paper and show how organisations require agility in their supply chains to provide superior value as well as to manage disruption risks and ensure uninterrupted service to customers. Thus the cultivation of agility is approached as a risk management initiative that enables a firm to respond rapidly to marketplace changes, as well as anticipated and actual disruptions in the supply chain. Agility is of value for both risk mitigation and response. Through the use of the structural equation modelling technique, partial least squares it is shown that strong linkages exist among the cultural antecedents, the three organisational practices considered, and the firm's supply chain agility. All three organisational practices, internal integration, external integration with key suppliers and customers, and external flexibility are shown to have significant positive impact on the firm's supply chain agility. The limitations of the study are this study only surveyed high-level supply chain professionals from individual firms, who are generally capable of internal and external assessments involving key suppliers and customers.

Khan and Burnes (2007) in their theoretical paper on risk and supply chain management, take the view that risk and uncertainty are not the same. They argue that whilst uncertainty may not be measurable; risk is both measurable and manageable. Another finding in their seminal paper is that most of the approaches for managing risk appear to fall into the broad categories of relationship management or strategic/ proactive purchasing. They argue that many writers see relationship management as the key to risk management. Thus communication and relationship management between tiers in the supply chain is important, not only at the level of the organisation but also at the level of the individual in the organisation.

Companies are increasingly recognising the importance of supply chain risk management. Supply chain risk management is an emerging discipline; whilst some

companies have improved their risk evaluation practices in recent years, much work remains to be done (Jayashankar and Brian, 2007). They argue that a full-time supply chain risk champion needs to be appointed who not only oversees and coordinates all supply chain risk activities, but also develops tools and best practices. The supply chain risk champion can be argued to be core to the relationship management and collator of information between supply chain tiers.

SCRM is at an early stage of evolution (Ritchie and Brindley, 2007). Supply networks are undoubtedly becoming significantly more messy units of analysis to deal with. These messy units that cause the dynamics of supply networks to be complicated to understand, also impact on risk. Whilst there has been substantial research attention to date on risk and on supply networks, there has only been limited empirical research on risk in supply networks. Ritchie and Brindley (2007) provide a brief review of risk, supply networks and risk in supply networks. Their paper summarised a tool that has been developed in an iterative, action research based way, and briefly reviewed the feedback from those involved in using the tool. Again, the “messy units of analysis” to deal with suggest empirical research into relationships between supplier tiers can be beneficial to the understanding of supply chain risk management.

Tang and Tomlin (2008) provide a structure to illustrate the power of flexibility for reducing supply chain risks. While it is clear that flexibility (agility) enhances supply chain resiliency, it remains unclear how much flexibility is needed to mitigate supply chain risks. Without a clear understanding of the benefit associated with different levels of flexibility, firms are reluctant to invest in flexibility especially when reliable data and accurate cost and benefit analysis are difficult to obtain. Long and complex global supply chains are usually slow to respond to changes, and hence, they are more vulnerable to business disruptions. In this paper, Tang and Tomlin (2008) focus

on three risks that are inherent to all supply chains, namely, supply, process, and demand risks. Supply risks include the risks associated with supply cost, supply quality, and supply commitment. Process risks include the quality, time, and capacity risks associated with in-bound and out-bound logistics and in-house operations. Demand risks include the risks associated with demand uncertainty. It is argued that more empirical work can be conducted to ascertain flexibility strategies to mitigate risk in the supply chain.

Manuj and Mentzer (2008) explore the phenomenon of risk management and risk management strategies in global supply chains. Their paper is based on a literature review and a qualitative study comprising 14 in-depth interviews and a focus group meeting with senior supply chain executives. This research makes three major contributions. The interaction of different risks in the global environment is explored. Second, a definition of risk management in a global supply chain context is developed. Rich descriptions of risk management strategies are provided and important antecedents to strategy selection are discussed. Third, three moderators in the process of risk management are explored, namely team composition, supply chain complexity management, and inter-organizational learning. The methodology of this paper suggests that qualitative studies are a valid way of exploring SCRM.

Neiger et al. (2008) argue it is important to address a critical gap in existing supply chain risk knowledge highlighted by the absence of a supply chain risk identification methodology that enables identification of organisational exposure to uncertainty. The objective of their paper is to address this gap by proposing such a supply chain risk identification methodology, thus making a contribution to the state of supply chain risk knowledge. The paper suggests that further work in risk identification can be empirically explored. Also the methodology to further progress the ideas

discussed in this paper, suggests future research directions include an empirical evaluation of the proposed methodology using action research.

Schoenherr et al. (2008) report the process used by a US manufacturing company to assess supply chain risks within the context of an offshore sourcing decision. The case study company was faced with the objective of finding a new supplier for two of its major product lines. Action research methodology was combined with the application of the analytic hierarchy process (AHP). Through iterative and structured discussions, 17 risk factors were identified, which were subsequently grouped into main and sub objectives. AHP was then used to evaluate the importance of each risk factor, and to determine the best alternative.

The final weight for each risk factor, representing its relative importance, is provided in Table 2.1.

Table 2.1: Risk Factors



Source: (Schoenherra et al., 2008)

The weights, which all add up to one, can be interpreted as follows. If a sourcing professional has 100 minutes to devote on the list of risk factors, then approximately 26 minutes should be spend on issues related to the optimization of product cost and the development of strategies associated with the mitigation of risk and uncertainty inherent in this factor. A further 25 minutes should be devoted to approaches ensuring product quality. The time allotted for the remaining 15 risk factors is 7 minutes or less each, stressing their relative unimportance compared to the first two characteristics. One of the motivations for this study was to aid a company in making the best sourcing decision, and to find answers to questions such as the following: How should we approach and make the outsourcing decision? What risks do we need to consider? How can we bring structure in this highly complex and challenging decision?

Trkman and McCormack (2009) argue that supply risk or the likelihood of supply disruptions is emerging as a key challenge to supply chain management. The ability to identify which supplier has greater potential of a disruption is a critical first step in managing the frequency and impact of these disruptions that often significantly impact on the supply chain. A single case study Dow Chemical Company is used. This paper suggests a framework for the assessment of supplier risk of disruption based on their strategy, structure, performance and attributes as modified by turbulence in their specific environment. A multiple case study involving an analysis of not only the suppliers of the focal firm but also the suppliers' suppliers would also be beneficial in future research; several studies usually focus on a dyadic relationship instead of a sequence or even a network of several firms in the chain.

Oke and Gopalakrishnan (2009) investigate the types and management of risks faced within the supply chain of a large US retailer. Based on relevant frameworks from the literature, the risks are categorised into inherent or high frequent risks and disruption or infrequent risks. Mitigation strategies for dealing with these risks, and the identification of generic strategies that could handle most risk types as well as specific strategies for handling particular risks are listed. The two questions that are identified are:

What are the different types of risks or potential risks in a retail supply chain?

What are the mitigation strategies required to manage these risks?

A case study research approach was chosen as the research strategy for investigating the research questions. Investigations into how risks types vary or are applicable at different points of a particular supply chain can be researched in the future. Other directions of research can question what are the trade-offs involved when implementing strategies to mitigate risks in supply chains? How can these be resolved? What are the quantifiable impacts of different types of risks? How do these impacts relate to which type of mitigation strategies is chosen?

Wallace and Choi (2011) have explored concepts such as robustness, flexibility, information structure, options, and market power for supply chain management. Despite many influential findings, such as the presence of the bullwhip effect and channel power, the literature in supply chain management is a bit confusing with regard to these concepts, including how they are related to each other. The main purpose of this article is to put the terms flexibility, robustness, information structure, options, and market power into a coherent package in the context of supply chain management under uncertainty. Information was seen as a key aspect of SCRM and

will be used and explored in this thesis through information management and the examination of information flows.

Guo (2011) analyses the characteristics of supply chain risk management under the influences of knowledge. He integrates basic theories and methods of knowledge management into the process of risk management, builds a knowledge-oriented supply chain risk management system model, and proposes relevant strategies, presenting references for practical application of knowledge-oriented supply chain risk management. The process of supply chain risk management will produce amounts of knowledge associated with supply chain risks, such as cause-effect relations, effects of risk events, and strategies of handling risk events. Knowledge is argued to be very important for supply chain risk management.

Wakolninger and Cruz (2011) develop a framework that captures the effects of information management and risk-sharing contracts in supply chain networks. In particular, they analyse the impact of strategic information acquisition and sharing on supply chain disruption risks and costs and evaluate the supply chain performance of risk-sharing contracts. Risk-sharing contracts specify who needs to incur the costs when supply chain disruptions occur. The research develops a model that consists of three tiers of multi-criteria decision-makers, manufacturers, retailers, and demand markets. Numerical examples highlight the importance of considering risk-sharing contracts as a tool to mitigate supply chain disruption risk. The examples stress the potential positive impact of information acquisition and sharing in supply chain networks. This research suggests that information management is a key aspect and SCRM and can be further explored.

Blome and Schoenherr (2011) use in-depth case studies conducted among eight European enterprises, and propose a set of propositions about how companies

manage supply risks in financial crises, they also highlight how their risk management approaches have shifted, and illustrate how they are related to Enterprise Risk Management. Even without the financial crisis, SCRM has become a necessity for many firms. Globalisation, improved infrastructure and information technology has led supply chains to become longer and more complex, resulting in higher supply chain vulnerability. The first proposition suggests how the financial crisis has impacted the way firms are pursuing the four enterprise risk process stages of risk identification, risk analysis, risk acceptance/mitigation, and risk monitoring. Recent events like the financial crisis in 2008 or the volcano eruption in 2010 have demonstrated again that risk events are inevitable and that they are even more likely to effect today's supply chains with their increasing global stretch and complexity (Juttner and Maklan, 2011).

2.5 Aerospace Supply Chains

Commercial aerospace manufacturing companies, producing large airplanes, are facing increasingly fiercer competition in the global marketplace (Rose-Anderssen et al., 2011). This calls for innovative solutions in terms of technologies, practices and products at the same time as reducing lead-time and costs.

Integration and coordination of inter-firm activities are essential to supply chain existence (Rose-Anderssen, et al., 2010). However, aerospace supply chains are characterised by different practices of integration and coordination. This defines different supply chain forms. As the industry is a conservative one, the changes to supply chain forms in the past are characterised by slow adaptation of practices from other industries. The integration of flow of information and materials between customers, manufacturers and suppliers defines the concept of a supply chain

(Samaranayake, 2005) becomes increasingly important if not critical. Risk sharing was highlighted to be important therefore this means this newly emerging supply chain form must be critically assessed to accommodate risk sharing activities. From both of these papers it can be seen that information management, in particular between suppliers and the OEM, can help to understand supply chain risk.

Rose-Anderssen, et al.'s (2010) paper addresses the integration and coordination processes of risk-sharing partnerships for one specific aerospace supply chain. The papers argument or hypothesis is that communicative interaction enhances the coordination and therefore the integration of the supply chain. This again is an important finding in relation to the themes for this thesis to be investigated in chapter 4. This is further supported by the notion that developing close relationships are collective processes (Rose-Anderssen, et al., 2008). These processes are characterised by dismantling those old routines that would inhibit relationships across company boundaries. The use of formal contractual risk-sharing partnerships can help negotiate how to collectively proceed. This can be a continuous process of questioning present practices and how they can be changed.

Emiliani (2004) discusses the use of online reverse auctions to source engineered components in global aerospace supply chains using online reverse auctions and examines the specific case where a U.S. economic cluster supporting large tier-one aerospace companies must compete against globally distributed sources of supply. The article also examines if global sourcing practices based on power-based bargaining is an intelligent or effective solution to market pressure demanding lower prices, or whether collaborative problem solving and the creation of knowledge-sharing networks offers greater potential for cost savings and improved long-term supply chain competitiveness. Key theoretical foundations supporting the use of online reverse auctions were shown to be wholly or partially flawed. Ultimately,

online reverse auctions do not help the buyer or seller understand the root cause of cost problems. This indicates the need for additional research to improve practitioner and academic knowledge of the domain of successful application for online reverse auctions.

Tannock, et al. (2007) argue that the aerospace industry offers particular opportunities to test the usefulness of a data-driven simulation approach due to the cost and complexity of the highly structured products, the high cost of holding inventory and the intricate interrelationships between businesses that can operate at several levels in the supply-chain. With the increasing complexity of supply chains in aerospace manufacturing, simulation has become a powerful tool to assess performance. Conventional simulation models are constructed by experts, limiting their usefulness for non-experts. Here, the concept of data-driven simulation is used, where the simulation model is constructed automatically using input data from company IT systems. Tannock, et al. (2007) describe the concept and operation of a supply-chain model builder that has been developed. An example model is provided from the civil aerospace sector. Future work could model other tiers of the supply chain and aerospace industry.

Cullen and Hickman (2001) describe how contractual relationships and contract documents relate to actual working relations. Their paper concentrates on the UK aerospace defence sector as in 1999. The Ministry of Defence introduced a radical approach to their acquisition process with the introduction of the 'Smart Procurement Initiative' (SPI) described in their publications on the acquisition process. The hypothesis is that dissonance exists, brought about by the SPI between the classical conflictual nature of contractual relations and the reality, of collaborative working relations that span institutional, corporate and disciplinary boundaries. It is suggested that future research should examine the role of contract documents and

wider elements of contractual relations in the context of SPI, with comparisons made between current practices in civil aerospace and other industries.

2.6 Supply Chain Knowledge Management

Al-Mutawah et al. (2009) describe how participating members in a manufacturing supply chain (MSC) usually make use of individual knowledge for making independent decisions. Recent research, however, indicates that there is a need to handle such distributed knowledge in an integrated manner, especially under uncertain and fast changing environments. MSC networks using a multi agent systems (MAS) approach, which is one of the distributed problem-solving techniques that is emerged from Artificial Intelligence (AI) research area. It is argued that MAS approaches have not adequately addressed the role of sharing tacit knowledge (TK) on MSC performance. This paper, therefore, aims to propose a framework that utilizes MAS techniques with a corresponding TK sharing mechanism dedicated to MSCs. Experiments are performed to simulate the proposed approach. The results showed significant improvements when comparing the proposed approach with another conventional MAS model.

Cheung and Myers (2008) argue that as firms face the pressure of global competition and increase their participation in a global economy, developing an in-depth understanding of supply chain networking issues becomes increasingly important. This study synthesises the findings in the literature with a multiple-case research design and identifies several potential opportunities, motivations as well as dilemmas that exist in a global strategic network. It proposes a framework to explore several factors that could contribute to the sustainability of a knowledge sharing network in global supply chains. These factors include: management fit, market-related fit, resource fit, shared identity, relational capital, and flexibility.

Choi et al. (2004) argue that with greater reliance on outsourcing has come a rise in the importance of supply chain and knowledge management principles. Intellectual property management in particular has gained importance. Licensing relationships are like those between buyers and suppliers, except that the former transact knowledge while the latter transact concrete materials and services. This analogy gives rise to five licensing models: stick (damage recovery), defence (posturing), carrot (attracting potential suitors), consortium (standard setting), and market (industry-wide usage). Adding to the literature, these models can be used as different lenses through which to view licensors/licensees in the area of IP management. When managing the knowledge supply chain, it is very important for licensees to understand the complexity of various licensing relationships and manage them effectively, just as with well-established buyer/supplier relationships.

Today there is a profound recognition by academics, researchers, and practitioners about the importance of managing knowledge in order to survive a constantly changing and fierce marketplace (Desouza et al. 2003). It is argued that viewing knowledge management using a process mapping akin to the supply chain perspective. Much, like the process mapping approach, in supply chains the research is concerned with how to get knowledge from one end of the organization to the other in the most optimal format. Desouza et al. (2003) argue that knowledge management can be viewed using a systems theory perspective.

Douligeris and Tilipakis (2006) argue that supply chain management has gained knowledge from the advance of Web technologies during the last decade. New applications as well as optimized existing applications have used the web as the medium to provide efficient and effective services to internal and external company users. The new paradigm in the universal World Wide Web is the semantic web, where the use of ontologies allows for knowledge management in ways that were not

possible before. Douligeris and Tilipakis (2006) describe these basic characteristic sets of ontologies and examine how the semantic web can provide considerable improvements over previously used paradigms.

Fletcher and Polychronakis (2007) propose a framework to capture and potentially disseminate knowledge in the supply chain. It is theoretically developed primarily from previous published work and empirically improved by further fieldwork within a sample of SMEs. Conflict exists over how knowledge should be captured, managed and disseminated by small to medium enterprises (SMEs) within any given supply chain. The literature review indicates the gap in knowledge management that exists generally in the industry and specifically within the SME sector in novel contexts of application. The field work further reinforced the literature findings within a sample of 40 SMEs from a number of industries.

Specifically, sharing knowledge among multiple entities in a supply chain is crucial according to Huang and Lin (2010). However, only a few studies have addressed the problem of interoperability and knowledge sharing in supply chains. Current technologies, such as EDI, Rosetta Net or the current Web, are useful for sharing data/information, rather than knowledge. This paper proposes a solution for sharing knowledge with the semantic web. The primary contribution of this paper is to solve problems of interoperability, and especially collaborative knowledge sharing in the supply chain, because of the nature of heterogeneous sources. A further contribution is that, during the annotation process is the semi-structured knowledge model used to externalize implicit knowledge in an explicit and sharable manner.

Action planning is far too frequently carried out relatively informally (Koh and Tan (2005). Companies might spend significant time developing strategies and objectives, which are then passed down to a manager to implement. This often

occurs in an ad hoc way based on the manager's past experience. A formal process provides a mechanism for combating this tendency. A formal process helped managers to decompose the complexity of uncertainty in manufacturing environments into manageable steps. The uncertainty diagnosing cause-effect business model provides a way of capturing and recording the operation of an organization in a way which can be easily accessed and to be shared with others. This allows a knowledge base to be built up over time, and revisited and amended as changes occur.

The concept of supply chain management has evolved from a narrow perspective, related only to material flows, to a broader view, encompassing material, and information, financial and technical flows, both within each organization and between organisations (Pedroso and Nakano, 2009). The goal of supply chain management is the smooth, seamless flow of goods, services and information across the constituent organizations. Demand information and material flows are intrinsically connected: demand information has to travel upstream the chain in order to create material or service flows, which are delivered to fulfil market needs. Thus, speed and accuracy are among the major concerns on managing information.

Despite that fact, research on supply chain management has given little attention to the study of technical information flows (Pedroso and Nakano, 2009). Most of the research on information in supply chain is related to studying the upstream flow of demand information and its effects on material flows. This paper aims to study the flow of technical information and understand its particular requirements. In some industries that flow needs to be managed apart from order information, using a specially designed path. That is the case of pharmaceutical companies: since customers do not have discretion over their purchasing decisions, depending on physicians' prescriptions, pharmaceutical companies need to keep physicians well

informed about drug development, in order to create demand. This research on pharmaceutical companies' supply chain clearly reinforces the importance of technical information flows and demonstrates their role on demand creation. It also emphasizes the need to keep technical information, order information, material and financial flows integrated and properly aligned.

Tah and Carr (2001) aim at developing a comprehensive and continuous risk management framework capable of enhancing the probability of project success, and to lead the industry to establish practices that are self-sustaining and continuously improving, grounded in effective continuous knowledge capture, re-use and learning. The objectives of this paper are:

1. To develop a common language for describing risks throughout the construction supply chain and covering the complete construction project lifecycle;
2. To develop a risk management paradigm involving identification, classification, assessment, analyses, action planning, tracking, control, and communication of risks on a continuous and proactive basis using the common language;
3. To develop tools using knowledge-based systems techniques to support the framework.

This research suggests that risk identification is important as well as having information management systems to identify risk in the supply chain.

In this paper, Tah and Carr (2001) highlight the shortcomings of current project risk management processes, tools and techniques, and identify the case for the application of knowledge management philosophies and techniques to project risk management. This formalism of describing project risks and mitigating measures coupled with knowledge-driven risk management will hopefully facilitate effective risk

handling whilst allowing all project participants to develop a shared understanding of project risks resulting in improved performance.

In the face of the transition of Mainland China to a more market-oriented economy, the question arises about how to build up and ensure efficient national innovation processes while at the same time avoiding innovation that is managed in a largely random fashion (Xiwei and Blein, 2010). To cope with uncertainties and risks, Xiwei and Blein (2010) propose analysing “knowledge networks” from a Supply Chain Management (SCM) perspective. Selected SCM methods and tools might prove to be useful in improving effectiveness and efficiency not only stage-by-stage but more importantly, over the entire chain or network. Turning ideas into practice, the paper suggests taking advantage of the years long experience with knowledge-based stakeholder information systems as a means to automate expert “opinion polls” via the internet. The design of a ‘rational risk assessment system’ could be a possible direction for future research in risk communication.

2.7 Social Network Perspective

The concept of ‘social networks’ is well established. Social networks have been used as constructs in social sciences since the 1950s (e.g. Hayashi, 1957; Mouton, Blake, and Fruchter, 1955). The features of the social network perspective have been summarized by Wasserman and Faust (1996). The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors allow the transfer of resources: physical or information based. Network structures are developed from combinations of these ‘dyadic’ relational ties between two actors. This thesis will focus on the social network perspective.

Network models explain structures in terms of lasting patterns of relations between actors. Combinations of relational ties can form 'paths' through the network by which non-adjacent actor nodes can communicate. The mathematical analysis of networks, either in the form of sociomatrices or topological networks, has formed the basis of a research perspective known as Social Network Analysis (SNA) that has been documented exhaustively by Wasserman and Faust (1996). Seminal work in applying concepts of social networks to management issues was undertaken by Krackhardt and Hanson (1993), with a summation of that experience presented in the Harvard Business Review. An example of a social network mapped out can be seen in figure 2.2

Figure 2.2: A Sample Social Network Map



Source: (Brookes et al., 2007).

The circles and squares in the map represent stakeholders, and the oval represents the respondents. The arrows represent the interaction between stakeholders and respondents with the figures representing the amount of interaction.

Social network theorists call upon a number of key constructs to describe and to analyse the social networks under their consideration (Wasserman and Faust, 1996; Conway and Steward, 2009). These include:

Size – The number of actors participating in a network. It can be argued that membership of a large network rather than a small network is better for exposure to novel information or even risk information. But network size cannot be considered in isolation from dimensions such as network density and network diversity, or network configuration.

Centrality – Centrality is a measure of the ‘importance’ of an actor node in the network. ‘Importance’ is either measured in terms of ‘degree’ centrality (the number of ties that an actor node has) or ‘betweenness’ centrality (the number of ‘shortest paths’ between network nodes that the actor node in question sits upon).

Density – Network density is calculated as the proportion of relational ties in a network to the total possible number of links between actor nodes in the network.

Reachability - A dimension closely related to density is that of reachability, which is defined as the number of links separating two actors in a network (Aldrich and Whetten, 1981; Tichy, 1981), or more generally, the average number of links between any two actors in a given network (Tichy et al., 1979) The denser the network, the lower the average number of links between two actors will be.

Diversity - This network dimension refers to the diversity of the actors within a network. With regard to networks of individuals, this might relate to one or more characteristics, such as profession, age, gender, or education, for example.

Openness – This dimension refers to the degree to which the actors within a network are connected to actors in other groups and networks. Closed networks are those with a group of actors who interact predominantly with each other and, as such, are characterized by the presence of many strong ties and few weak ties. In contrast, open networks embrace both strong ties between a core group of actors, as well as a set of weak ties with a subset of individuals from that core group and other groups.

Stability - Many network studies represent a snapshot of a network at a particular point in time but networks are not static. Indeed, many networks are highly dynamic in relation to their size, membership, and density, for example. Staff turnover in an organisation can lead to a unstable network, with new members of staff having to rebuild networks.

Relational tie characteristics – The ties between actor nodes can be characterised along a number of dimensions. These are known as relational tie characteristics. A link between two individuals or organizations may, in part, be described and understood in terms of the nature of the ‘tie’ or ‘bond’ that maintains the relationship (Conway and Steward, 2009). In relation to individuals, the research distinguishes between:

- ‘instrumental ties’, through which mutually rewarding ‘economic’ exchanges of information, goods, and money, for example, occur. Information can be seen as an important aspect to be explored within this thesis;

- 'affective ties', through which satisfying emotional sentiments, such as friendship, can be evoked;
- 'moral ties', within which a 'code of fairness', 'social banking', and 'reciprocity' are the main binding forces (Kanter, 1972).

With respect to organisations, the following set of categories can be explored:

- 'technical bonds', related to the technological links between two organizations;
- 'knowledge bonds', concerning the knowledge that two organizations have about each other's operations;
- 'social bonds', referring to the personal links and trust between individual members of two organizations;
- 'administrative bonds', related to the interconnectedness of administrative procedures and routines between two organizations; and
- 'legal bonds', in the form of contractual obligations between organizations (Hakansson and Johanson, 1990).

In both of these typologies, the categories are not mutually exclusive, such that a relationship between two individuals, for example, might include elements of instrumentality, friendship, and reciprocity. Furthermore, where more than one type of bond or tie is present, the relationship is likely to be stronger and more enduring.

An important element of relationships is trust. Trust is central to the maintenance and development of relationships, and to the sharing of information, knowledge, and other resources between actors (Conway and Steward, 2009). Trust may be viewed as 'a state of mind' regarding the expectation that 'the other' will act reliably and fairly, and exhibit goodwill when unforeseen circumstances arise (Sako, 1991; Dyer and Chu, 2003). Within social networks, trust is higher where the ties between

individuals are strong rather than weak and is reinforced in dense networks where an individual has more to lose from a reputation of low trustworthiness (Krackhardt, 1992; Castilla et al., 2000). Higher trust is associated with a greater willingness to share and disclose information and knowledge.

In 1973, Granovetter's seminal paper, *The Strength of Weak Ties*, argued that differing relational characteristics pertaining to the strength of relational ties enabled innovations to flow through a social network. The potential for social network concepts to impact upon product development, in particular global product development, has been recognized since the mid 1990's (Brookes, et al., 2007). A wide range of studies (Rosenthal, 1996; Huang and Newell, 2003; Bond et al., 2004) have all supported the proposition that the structure of a social network could affect product development performance. Many of these studies have either specifically focused on NPD teams directly or have considered related issues of group performance or knowledge sharing required for effective NPD team performance. (It should be noted that the links between social capital, social networks and new product development are not always identified as beneficial.) In many cases the focus of investigation has been the ability of a social network structure to carry knowledge.

The transfer of knowledge between individuals has been shown to be dependant on both the social network structure that an individual possesses and the relational nature of the ties within that network (Reagans and McEvily, 2003; McEvily and Zaheer, 1999; Cross and Cummings, 2004). For example, Hansen has shown that strong relationships facilitate complex information transfer (Hansen, 1999). Constant et al. (1996) have shown that weak ties carry technical information.

In contrast to the use of social network theory in innovation and new product development research, the application of social network construct to the management of supply chains is not well developed. Lamming, et al. (2000) in articulating the construct of a 'supply network' do call upon the concept of a 'social network' but use it in a very narrow sense to describe a sub-set of networks based on personal parity and use examples of industrial clusters and some sub-contracting relationships. Their usage of the term 'social network' does not articulate or incorporate any of the concepts normally associated with social network theory.

A number of articles in the Marketing and Operations Management bodies of research literature have begun to utilise relational tie constructs in describing supply chain structures. Wathne and Heide (2004) describe dyadic relationships in a garment manufacturing supply chain and the implications of these relational dyads on the approach to marketing in this context. Cousins, et al. (2006) conceptualize the relationships between buyer and suppliers as relational dyads and describe how relational 'capital' can be garnered and utilised across these dyadic relationships. Lazzarini, et al. (2001) introduce the concept of 'Netchain Analysis.' A netchain is a set of networks comprised of horizontal ties between firms within a supply chain which are sequentially arranged based on vertical ties between firms in different layers. In developing the 'netchain' concept, they refer explicitly to both social network theory and supply chain structuring. They state:

"Even though both Supply Chain Analysis and Network Analysis stress the importance of interdependencies between multiple firms and how interorganisational relationships can be a source of competitive advantage, the integration of their core concepts and analytical tools is still to be done."
(Lazzarini, et al. 2001, page 7).

2.8 Using Social Network Theory in a Supply Chain Context

Galaskiewicz (2011) highlights that there is an important difference between those who study networks as a collection of arcs and nodes and focus on the formal properties of different configurations and those who study social networks. That is researchers that look at behaviour and have tested those using organisations and individuals as the units of analysis and network methodology. This section will look at this aspect of the social network perspective.

Galaskiewicz (2011) argues that there has been little research done into social network analysis in the supply chain, and goes on to say that social network analysis can add value to the supply chain management literature. He argues that social network ties between organisations in the supply chain are important in building trust amongst the individuals that can therefore facilitate information exchange, cooperation and coordination.

The first step in utilising social network theory in a supply chain context is to determine an appropriate 'unit of analysis'. As Tichy, et al. (1979) outline in their seminal paper, using social networks in an organisational context demands that the user identifies what social 'unit' each actor node in the network represents. A supply chain could incorporate a wide range of units of analysis:

- Between individual people
- Between organisational groupings (at different levels of granularity)
- Between whole organisations
- Between 'tiering' of organisations

The applications of social network theory presented in this thesis will focus on organisational networks and on individual social networks. At an individual level, this thesis explores how the social networks established between individuals can identify supply chain risk.

Yusoon et al. (2011) argue that supply chain management has focused on linear relationships of buyers and suppliers. While a linear perspective may be useful for planning certain mechanical aspects of transactions between buyers and suppliers, it fails to capture the complexity needed to understand a firm's strategy or behaviour, as both depend on a larger supply network that the firm is embedded in. A firm's "supply network" consists of ties to its immediate suppliers and customers, and ties between them and their immediate suppliers and customers, and so on. From a supply network perspective, the relative position of individual firms with respect to one another, influences both strategy and behaviour.

Yusoon et al. (2011) show how social network analysis can both supplement and compliment more traditional, qualitative interpretation methods when analyzing cases involving supply networks. They apply a framework to real supply network data derived from three published case studies of automotive supply networks. In this study there is a theorising and empirically investigation into supply networks using SNA concepts. The study is limited in ways that suggest opportunities for future research. First, the analysis is confined to a specific automobile module (i.e., center console assembly). Any one supplier in the supply network might be involved in several overlapping supply networks across different product lines. A supplier's role based on one supply network will look quite different from that derived by considering the multiple supply networks together it is a member of. Therefore, the central roles a supplier plays in our analysis should be qualified to the single product

line. Future research could take advantage of the usefulness of SNA for untangling and understanding the complex phenomena embedded in supply networks.

Capo-Vicedo, et al. (2011) in their paper iterate a proposal of an organizational form based on social networks (SN) that takes full advantage of knowledge management benefits. This work uses the social networks analysis (SNA) techniques as a modelling tool to better understand knowledge management in a multi-level supply chain. The findings of this paper provide useful insights into how supply chains formed by SME can reinforce their collaborative behaviours and activities to not only enhance their relationships, but to also achieve competitive advantages for the supply chain as a whole. The paper starts by reviewing the literature on knowledge management (KM) at the inter-organizational level to study the particular case of the SC formed by SME and the importance of the network concept to improve the KM process at this level. Furthermore, the paper suggests a new organizational form based on SNA to gain a better understanding of the KM process, and it also studies the case of a construction supply chain. The paper uses SNA in a quantitative manner, so future research could use qualitative methods to analyse the social network perspective.

2.8.1 Using Social Network Concepts to Model Holistic Complex Supply Chains

Existing approaches to modelling and designing global supply chains have been extensively reviewed by Meixell and Gargeya (2005). They have established an over-arching supply chain model that embraces the decisions inherent in the extant literature on global supply chain modelling and design. However Brookes and Lewis (2006) use an empirical case-study investigation in the aerospace industry to

highlight the inadequacies of existing approaches to modelling supply chains. These included:

Multi-Tier Supply Chain Elements: Suppliers of materials featured at every tier in the supply chain. For example, all tiers of the aerospace supply chain (company, customer and supplier) were likely to use composite materials from a small defined group of suppliers. The appearance of the same organisation at every tier of the supply chain is difficult to explore using conventional supply chain models

Cross-Supply Chain Interactions: The featuring of a supplier in a competitor's supply chain needs to be captured in a model so that potential inimical effects can be identified and accommodated. Many current approaches to modelling supply chains fail to capture interactions between supply chains.

Reverse Flows in Supply Chains: The combination of global environmental legislation (e.g. the European Unions WEEE directive) and the move towards whole life-cycle care of products that servitisation demands has led to the need to capture bi-directional and complex flows within supply chains. For example, the aerospace industry is facing is the rise of independent 'Maintenance Repair and Overhaul' (MRO) independent contractors. Maintenance, Repair and Overhaul is an activity traditionally performed by the aerospace OEM (original equipment manufacturer) after the product has entered into service with the customer. Involvement in MRO and the accompanying spares provision has played an important part in aerospace OEMs profitability. The effect of complex bi-directional flows of materials on supply chain needs to be understood and current approaches do not incorporate this facility.

When modelling supply chains as social networks, one could use actor nodes to represent separate organisations or significant organisational sub units. Relational

ties between organisations could be used to represent flows of material, information, money or other transactional attributes that are transmitted across the supply chain. Combination of relational ties into a 'path' could represent a supply chain.

Through the simplicity of combination of multiple relational 'dyads', social network approaches can provide much of the functionality identified as required by Brookes and Lewis (2006):-

- Social network models allow actors to interact in a multiplicity of ways. Furthermore, they allow the model to distinguish between actor categories (for example, by ownership of organisation or by product/service type provided.) This allows the model to simultaneously capture different supply chains and the interactions between them.
- Social network models allow for a multiplicity of bi-directional relational ties that allow the model to capture the type of complex reverse flows associated with 'whole life cycle effects' on supply chains.
- Social network models allow relational ties to carry a wide range of information. Ties could be used to encapsulate 'classical' constructs such as average lead-time of the transaction but can also be used to capture more behavioural aspects such as levels of trust or perceived risk in a transaction.

A number of pre-existing automated tools are in wide usage to model social networks generally and should be able to be readily adapted for a supply chain context.

Additionally, the constructs used to analyse social networks involving centrality and density also can yield insight when applied to social network models of holistic complex supply chains:-

Centrality: Centrality can be used to identify vulnerabilities (and hence sites of highest potential risk) in supply chains. 'Degree' centrality in this context represents the number of supply chain interactions that an organization has. Simplistically, the greater the number of interactions, the higher the probability that disruption of the actor node organisation will cause widespread disruption of the whole supply chain. 'Betweenness' centrality indicates the distance between tiers of interaction. If an organisational node displays high level of betweenness centrality, it means that not only does that node have a high level of interaction but that those interactions are with very close tiers of the supply chain. This indicates an even more risky situation because there will be minimal lag or buffering along the particular supply chain paths in question to counteract the effects of any disruption at the actor node. Analysing the centrality of nodes in a supply chain social network provides a mechanism to identify the points of highest network vulnerability and risk.

Density: Density in the context of a social network model of a supply chain represents a quantitative measure of the level of complexity. Highly dense models indicate large numbers of 'multi-tier' interactions. Sparse models indicate relatively 'linear' supply chains where constructs of 'whole chain' ownership can have much greater validity and relevance.

Both density and centrality could be used to characterise typological archetypes of supply chain structures to provide a portfolio of contingent approaches to supply chain management.

2.9 Typology of Types of Ties Amongst Persons Studied in the Social Networks Literature

Borgatti and Li (2009) argue that network concepts can be applied to both “hard” types of ties (e.g., materials and money flows) and “soft” types of ties (e.g., friendships and sharing-of-information), both are important (and mutually embedded) in the supply chain context, see figure 2.3. They summarise the types of ties from a study in the social networks literature.

Figure 2.3: Typology of Ties



Source: On Social Network Analysis in a Supply Chain Context, Borgatti and Li (2009)

At the top level, the typology divides ties into two basic kinds, continuous and discrete. Continuous ties are those that are always “on” for the duration of the relationship, such as being the spouse of someone. Another way to think of continuous ties is as relational states. In contrast, discrete ties are based on a series

of discrete events, which we might count up, such as the number of times X sends Y an e-mail, or the number of bits of information transferred from one place to another. The discrete information flows are particularly relevant to this thesis and research aim of how to identify disruption risk in an aerospace supply chain through the examination of information flows and social networks analysis.

At the next level, the typology divides ties into four major groups: similarities, social relations proper, interactions, and flows.

The types of ties are studied further and are distinguished between types of tie, firms as entities and individuals in table 2.2.

Table 2.2: Examples of Inter-Organizational Ties Cross-Classified by Types of Ties (Rows) and Type of Entity Involved (Columns)



Source: On Social Network Analysis in a Supply Chain Context, Borgatti and Li (2009)

As discussed earlier, it can be seen in the table the types of ties can vary between the firms as an entity, but also between individuals. This thesis will look at the flows between individuals in particular.

2.10 Push and Pull Information and Knowledge Management

There is a lack of models in analysing the supply chain risk associated with information flows, possibly due to the omission of appropriate modelling techniques in this area (Tang and Nurmaya, 2011). These findings were found from a literature review of supply chain risk papers. Jorge (2009) suggests avenues of future research into how information management, IT and unpredicted interventions and sources of instability in the supply chain can be modelled. The importance of information management and the supply chain is also highlighted (Jorge, 2009). In the paper by Wakolbinger and Cruz (2011) they develop a framework to analyse the impact of information acquisition and sharing as well as risk-sharing contracts on production and transaction costs and disruption risks in competing supply chains. They look at risk sharing contracts as one way in which to mitigate disruption risk in the supply chain (Wakolbinger and Cruz, 2011). However, the types of information flows are not investigated, in particular the push and pull aspects of information flows.

Gibson (1997) suggests that within news gathering on the internet, many users still prefer a pull type information approach, rather than being pushed daily information. However, research in a number of news organisations, suggests that there needs to

be a combination of push and pull type information feeds to cater for the different needs of individuals. Malhotra (2005), researches how integrating knowledge management strategy and technologies in business processes for successful performance. The research suggests that there is a superiority of strategy-pull models made feasible by new plug and play information and communication strategies, over the traditional technology push models. The research suggests that the propositions “getting the right information to the right person at the right time” needs to be addressed alongside, the question of what knowledge to manage and towards what end.

Edwards, et al (2005) explores the role of technology in knowledge management in organisations, both actual and desired. Findings of empirical research found that organisations need to resolve four tensions:

- Between the quantity and quality of information/knowledge
- Between centralised and decentralised organisation
- Between head office and organisational knowledge
- Between push and pull processes

There is a tension between pushing information and knowledge out to people and leaving them to pull it when needed. There was general agreement, in the research, that universal push systems did not work. Other literature supports this, such as Damodaran and Olphert (2000). Holtshouse (1998) suggests the need to balance push and pull approaches. Certain people are more likely to choose to pull knowledge for themselves, than others are. The research questions, how do you involve those who might least wish to be involved

2.10.1 Information Push and Pull

On the internet (Herman, 2010), there are two ways in which information can flow from source to consumer:

Information Pull, where a consumer or user takes (or is given) the initiative to get it;

or

Information Push, where a supplier takes (or is given) the initiative to deliver it.

These definitions can be further applied to supply chain information management. From the early days of the Internet up until now, information pull has been the most dominant force in the information market. A few years ago, this meant that consumers of information would take the initiative to visit a site/to get information. They got there by casual browsing the internet, because it was recommended by someone else (e.g. in a Usenet article), or by some other way. As the number of sites and services on the internet began to rise dramatically, information pull - in this form - began to lose its appeal and power as it became too time-consuming and too laborious. As search engines and directory services (such as Yahoo) appeared on the internet, they were able to restore most of information pull's appeal, but this effect is now gradually wearing off.

Information push in the form of push technology arrived on the Internet in the form of such applications as *PointCast* and *BackWeb* (Herman 2010). Its promise was to offer a strong alternative to information pull, and the not-so user-friendly search engines. Until today, Push Technology has not been able to live up to all of its expectations and claims. Although it is not completely "dead", as a number of online

news papers have written, Push Technology has become more of a niche product. It can be interesting for certain groups of people and push capabilities are (being) built into numerous applications and services (e.g. many Web sites use it to keep their readers in touch with what has changed on or what has been added to their site). Yet, it has not been able to become the dominant way of getting information online. However, information push, in general is quite popular, at least in the form of mailing-list; using mailing-lists only require an e-mail program to use them, and the information as received through them usually does not contain a lot of noise (such as 'spam') or other irrelevant information (Herman, 2010). Most of this research is based on the internet, in terms of push and pull information management, however it can also be applied to the discrete information flows between organisations and individuals within the supply chain as discussed in the previous section on social networks and typologies.

2.11 Literature Research Findings and Issues

The literature review has identified a number of research issues and areas of research that can be further developed.

The literature highlights that good communication and relationship management are important factors in reducing supply chain risk (Mitchell, 1995; Condon, 2007, Juttner, 2005; Juttner, et al, 2003; Zsidisin et al., 2000; Khan and Burnes, 2007). However, little research has been done on actually examining the information flows that lead to risk. This point is particularly important since literature suggests that most strategies to identify and mitigate supply chain risk are expensive, i.e. to reduce risk one can build buffers in all interfaces to other companies, but doing so is expensive in the short run (Sorenson, 2005). "The better sharing of information is

the key. Information is always the cheaper thing to share, rather than having spare capacity or inventory.” (Condon, 2007, page 55). Mohd Nishat et al. (2006) stress that information sharing, communication and coordination among all elements of the supply chain are essential to its success. Supply chain resilience to changing conditions can be improved by frequent communication between tiers (Christopher and Peck, 2004).

The social aspects of a supply chain were mentioned by a few writers, such as Kasi (2005) and Burgess and Singh (2006) as not being modelled by current methodologies for analysing supply chains, such as the Supply Chain Operational Reference Model (SCOR). This finding combined with the better use of information to identify and mitigate risk, suggest that social network analysis can be important to identifying and mitigating risk. Social networks are important in transferring information as summarized by (Wasserman and Faust, 1996). Considering supply chains as a network of relationships (Harland, 1996) leads us to believe that social networks are particularly important in the context of supply chains. The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors allow the transfer of resources: physical or information based.

Khan and Burnes (2007) suggest future research to develop models of supply chain risk management can use risk management tools and techniques from other disciplines of research. This may support the use of social network analysis through the use of a tool to identify risk in the supply chain. The literature supports the development of tools to identify and mitigate risk, for example, Juttner (2005) found that less formalised tools are more popular than formalised ones to help identify and assess risk. Ritchie and Brindley (2007) go on to argue that to conduct empirical

research on risk in complex supply networks, tools are required for identifying, assessing and managing risk.

Social network information can be used in both a push and pull basis to identify risk. The question that arises is, similar to that regarding knowledge and information management, online and in general, is that which the most appropriate form of information management is. As discussed earlier, this will depend on the merits of each type of information delivery system, and the type of information, as well as the preference and need of the recipient of the information (Herman, 2010). Research within the areas of knowledge management and information management, suggests that:

- Pull type of information management is more popular than push (Damodaran and Olphert, 2000).
- Universal push types of systems do not work (Edwards et al., 2005).
- There is a need to balance push and pull approaches (Holtshouse, 1998).
- Certain people are more likely to choose to pull knowledge for themselves, than others are, dependent on their needs (Holtshouse, 1998).
- How do you involve those who might least wish to be involved (Holtshouse, 1998).
- Many suppliers of push type of information still have to depend on their own creativity to reach the right users (Herman 2010).

It can be seen that examining information flows in terms of push and pull will be beneficial to understand the dynamics of information flow within social networks when looking at supply chain disruption risk.

2.12 Discussion of Themes

The two themes that have been developed from the literature findings and OEM discussions are:

- Social networks can be used to gather supply chain disruption risk information
- Supply chain disruption risk information flows can be identified by exploring triggers that identify risk through the concepts of information “push” and “pull”

Social networks can be used to gather supply chain disruption risk information as highlighted by the initial exploratory discussions with the OEM and learning about the retrospective case study of disruption in the supply chain due to a bankruptcy of a supplier. This, combined with the literature review, suggests that social networks can be used to transfer information, but more specifically they can be used to gather risk information in the supply chain. The application of the social network perspective has not been explored in previous research when looking at supply chain disruption risk management.

The information flows in an organisation are important to analyse how risk information is managed by the organisation. Triggers to identify risk can be explored to analyse how supply chain risk information is first received into the organisation. Thus by analysing the triggers that first alert an individual of a supply chain disruption risk, we can identify the information flows through which supply chain risk

is received in an organisation. Such information can be pushed or pulled into the organisation.

2.13 How Does the Literature Review Lead to Exploratory Themes?

Social networks are important in transferring information; this was argued by Wasserman and Faust (1996). Furthermore, it was seen that the types of ties relate to the flows of information also (Borgatti and Li, 2009). It can therefore be seen that social networks are an important means of transferring information. Empirical case studies need to be done to investigate how companies manage supply chain risk. Whilst there has been substantial research attention to date on risk and on supply networks, there has only been limited empirical research on risk in supply networks (Ritchie and Brindley, 2007). Galaskiewicz (2011), argues that there has been little research done into social network analysis in the supply chain, and goes on to say that social network analysis can add value to the supply chain management literature. He argues that social network ties between organisations in the supply chain are important in building trust amongst the individuals that can therefore facilitate information exchange, cooperation and coordination.

Mohd Nishat, et al. (2006) stress that information sharing, communication and coordination among all elements of the supply chain is essential to its success. The importance of information sharing was evident in this paper. This combined with the use of social networks suggests that social networks can harness and transfer information more effectively within the supply chain.

Sheffi (2005) examined the ways in which companies can recover from high-impact disruptions and focused on actions to lower vulnerability and increase resilience.

These included reducing the likelihood of disruptions through monitoring and detecting weakest signals. These weakest signals can also be seen as triggers of risk, as argued by Harland, et al. (2003), who go on to say that the likelihood of an event occurring depends partly on the extent of the exposure to risk and partly on the likelihood of a trigger that will realise the risk. Assessment of risk must therefore involve the exposure and triggers to risk. Kleindorfer, et al. (2005) mention using preemptive/alerting triggers to identify risk in their paper on managing supply chain disruption risks, however they do not expand upon what these triggers may be.

The processes and techniques that companies use to identify and analyse risk in their supply chains need to be analysed through empirical case studies. Khan and Burnes (2007) argue that in the area of SCM, risk is less understood than in other disciplines and less developed. They suggest that empirical case studies to investigate:

- How do companies manage supply chain risk
- What processes and techniques do companies use to identify and analyse risk in their supply chains

Knowledge Management and Information Management refer to push and pull information management which closely relates to information flows between social actors in social networks

Knowledge management strives to develop knowledge-pull within an organisation by creating a strong demand for new knowledge (Maqsood et al., 2007.). This would reduce the struggle that researchers have to push knowledge into organisations; rather the organisation itself would be demanding (pulling) knowledge from the research community to develop productive innovations - products, tools and

techniques. This would be then reflected by a decreasing gap between research outputs and its practical application in the industry.

In summary, the research issue that will be explored is if improving information flows, especially through the use of social networks, can reduce supply chain risk. Supply chain disruption risk information flows can be identified by exploring triggers that identify risk through the concepts of information “push” and “pull”.

The two themes that have come out of the literature review and retrospective case study in the OEM suggest that a methodology needs to include methods which could use these aims and further develop them into theoretical propositions.

2.14 Chapter Summary

This chapter has looked at the literature on supply chains, supply chain risk management, social network analysis and knowledge and information management. There is literature on all of these aspects; however there is limited literature that combines all these approaches to identify and therefore mitigate disruption risk. The OEM experiences suggest that this is an important area of research, as discussed in the previous chapter. Practitioners experiences suggests that an academic study of this area should be further explored, this combined with the literature findings, suggest the themes of the thesis can be developed around the concept of disruption risk in regards to social networks and the examination of information flows.

This chapter has also explored the two research themes that have been derived from the literature review in the previous chapter and also from the retrospective case study discussions with the OEM. The research needs to further expand and research

these themes and develop them into propositions. The next chapter will explore the methodology of the thesis, and explore how the themes can be developed into propositions and then be explored further.

Chapter Three - The Research Methodology Framework

3.0 Introduction

The previous chapter has explored the literature and developed research themes for the thesis. This chapter will now look at the methodology for the research and how the theoretical propositions can be developed and tested. The philosophical background to the research themes will be explored first, which will be followed by a discussion as to the importance of the research approach, deductive versus inductive. The methods for analysis will be then explored with an exploratory case study investigation in the OEM allowing the development of research propositions. The testing of these propositions will then be explored via the use of focus groups within the OEM and an academic setting.

3.1 Methodology Summary

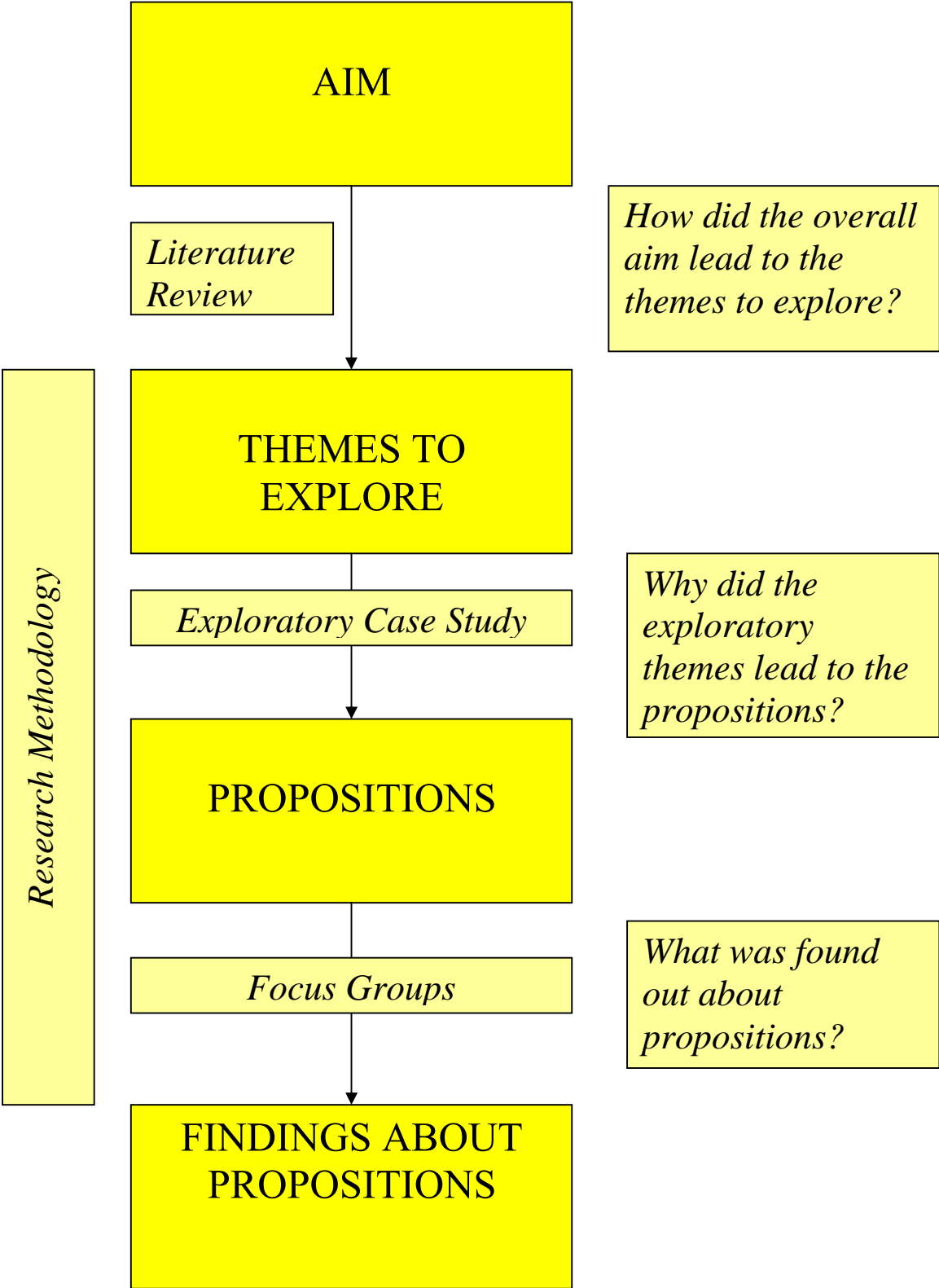
The research investigation began with a literature review, explored in chapter two, to find the key issues in the literature regarding mitigating risk in the supply chain. This also allowed the research to develop the research questions required for the research and the consequent case study, as identified by Yin (2002). This will be outlined in the following sections.

The overall framework of the research consists of a two-phase methodology. The first phase being an exploratory case study, at the OEM and their suppliers, which would include thirteen interviews at the OEM and secondary data collection, in respect of a retrospective case study. This was followed by conducting two supplementary cases, with one interview in each, conducted in two first tier suppliers

of the OEM. The aim of this was to look at the differing perceptions of risk between the OEM and suppliers. The second phase was a focus group investigation which would extend and validate the theoretical findings and propositions from the first phase of the research. This consisted of four focus groups, two at the OEM and two in an academic setting. The methodological framework can be seen in figure 3.1.

Exploratory case study research was selected as a method for analysis in relation to the initial research issues regarding if improving information flows, especially through the use of social networks, can reduce supply chain risk. Also supply chain disruption risk information flows can be identified by exploring triggers that identify risk through the concepts of information “push” and “pull”. Exploratory research was conducted because the literature review found no empirical research was available on identifying and mitigating risk in the supply chain through the use of information flows and social networks. A case study methodology was well suited to this stage of exploratory research. This phase of the research consisted of an initial case study in the OEM as an exploratory study to identify the issues raised from the literature review in a practical setting. This was done via semi structured interviews designed with questions chosen from the literature review issues, as well as guidelines from Kvale (1996).

Figure 3.1: Research Methodological Framework



Semi structured interviews were conducted with personnel from the OEM from stakeholder departments namely Purchasing, Engineering, Strategic Sourcing, Operations and Finance. A more detailed composition of this sample will be described later in this chapter. Interviewees were asked to identify components which to them typified the types of supply chain risk that the company encountered and to explain their rationale. Interview transcripts were then analysed using Kreuger's (1994) guidelines for qualitative analysis and coding, to identify the emergent themes that linked interviewee's experiences.

Once the transcripts of the interviews were initially analysed, four further case studies were chosen from the OEM's suppliers, based on characteristics which were found to be central to the theory that was being proposed, developed from both the literature review and the exploratory case study in the OEM. These four studies selected were reduced to two case studies, due to factors which will be discussed in chapter four. The multiple case study criteria, as proposed by Yin (2002), were used to analyse and compare these two case studies; again semi structured interviews similar to the exploratory case study were used in this phase of investigation. As only two of the companies responded to this phase of interviewing, this thesis is based on one single case at the OEM and is supported by two supplementary cases in the supply chain of the OEM.

The next stage of the research, as illustrated in figure 3.1, was to define the findings in the form of theoretical propositions based on the case study experience. The second phase of the research was to test the findings from the initial exploratory research in an organisational and academic setting. Focus groups were selected as the method to achieve this.

The selection of a two phase approach to the research design is mainly driven by the need to test the propositions found from the initial phase. The second phase was seen as important to discuss the propositions and see if they reflect the findings from the initial exploratory phase. Focus groups were found to be the ideal way to do this. The use of discussion would allow the propositions to be analysed through examples and individual and collective views. The thesis thus will use exploratory semi structured interviews followed by focus groups to improve the rigour and triangulation of the research as endorsed by Lambert and Loisel (2008) from an investigation using focus groups and interviews. The use of both practitioner and academic focus groups were used to compare practitioner views and see if they offer distinctive insights or commonalities from academic focus groups. These will be discussed in chapter five. The OEM Managing Director, being the sponsor of the research, was also keen to see the differences between an organisational settings and views from experts, as described by Miles and Huberman (1994).

3.2 Philosophical Underpinnings of Research

3.2.1 Evaluation of the Discipline

The theory behind this thesis is quite unique in that it falls into five different disciplines; risk management; supply chain management; operations management; social network analysis and information management. Whilst conducting a literature review, it was found that most of the literature concerning research paradigms fell into the operations management discipline (Boyer, 2008; Coughlan and Coughlan, 2002; Filippini 1997; Meredith, 1998; Meredith, 2001; Meredith, et al. 1989; Pannirselvam, et al., 1999).

One could argue that risk management and supply chain management are sub-sets of operations management; therefore, this section will look at the paradigms and methodologies that relate to operations management. However, the social issues relating to social network analysis will also be explored. This thesis will use the 'Research Onion' framework (Saunders, et al. 2007) as illustrated in figure 3.2

The philosophy of the thesis will be discussed followed by a look at deductive versus inductive research approaches. This will be followed by identifying the strategy of research (case study) and the choice of research method (multi-method) and finally the data collection methods (interview and focus groups) and the method of data analysis (thematic analysis).

Hussey and Hussey (1997), provides a comparison of the positivist and interpretivist paradigms. Some of the issues connected with the interpretivist paradigm, which can be seen to be reflected in this thesis are as follows:

1. Tends to produce qualitative data
2. Uses small samples
3. Concerned with generating theories
4. Data is rich and subjective
5. The location is natural
6. Reliability is low
7. Validity is high
8. Generalises from one setting to another

Source: (Hussey and Hussey, 1997)

Thus, the thesis underpinnings can be argued to be an interpretive paradigm.

Figure 3.2: The Research Onion



Source: (Saunders, et al. 2007)

3.2.2 Research Paradigms

This section will also use the arguments mentioned in the RMC II lectures and selected papers, and books, to analyse the elements of the research paradigm i.e. epistemology philosophies, ontology philosophies, and methodology strategies used in the thesis. Ontology is the 'reality' that researchers investigate , epistemology is

the relationship between that reality and the researcher, and methodology is the technique used by the researcher to investigate that reality (Healy and Perry, 2000).

Following on from research paradigms research (Guba and Lincoln, 1994), four main paradigms can be identified:

1. Positivism
2. Critical Theory
3. Constructivism
4. Realism

The four paradigms and their elements are summarised in Table 3.1.

Table 3.1: Four Categories of Scientific Paradigms and Related Elements



Source: (Healy and Perry, 2000)

Some authors (Hussey and Hussey, 1997; Saunders, et al. 2007) would argue that the main paradigms that dominate research are positivist and interpretivist. These two paradigms can be seen to be two extremes on a continuum (Hussey and Hussey, 1997). Positivism relates to the philosophical stance of the natural scientist

(Saunders, et al. 2007), this entails working with observable social reality and the end product can be law-like generalisations similar to those in the physical and natural sciences. Interpretivism advocates that it is necessary for the researcher to understand the differences between humans as our role as social actors (Saunders, et al. 2007).

As well as the two dominate research paradigms, other literature presents other paradigms along the same continuum, such as Healey and Perry (2000). Meredith, et al. (1989), present their own views of research paradigms within operations management. Their model has two key dimensions, rational/existential dimension and the natural/artificial dimension, see figure 3.3. This rational/existential dimension relates to the epistemological structure of the research process itself. It involves the benefits and limitations of the philosophical approach taken to generating knowledge; that is, the viewpoint of the researcher. At one extreme is rationalism, which uses a formal structure and pure logic as the ultimate measure of truth. At the other extreme is existentialism, the stance that knowledge is acquired through the human process of interacting with the environment. The natural/artificial dimension concerns the source and kind of information used in the research. At the natural end of the continuum is empiricism (deriving explanation from concrete, objective data), while at the artificial end is subjectivism (deriving explanation from interpretation and artificial reconstruction of reality).

Figure 3.3: A Generic Research Paradigms Model in Operations Management



Source: (Meredith, et al. 1989)

3.2.3 Research Methodologies - In Operations Management

Meredith, et al. (1989) go on to develop a framework for research methodologies in operations management. The methodologies used in terms of the paradigm can be seen in table 3.2. Healey and Perry (2000), also develop a range of methodologies that fit within research paradigms, and can be seen in figure 3.4

Interviewing can be argued to be used by the realism paradigm (Healy and Perry, 2000), and the interpretivist paradigm (Saunders, et al. 2007). Statistical methods can be seen as an element of positivism, see figure 3.4.

Meredith et al. (1989) also argue that action research and case studies fall into the interpretive dimension see Table 3.2.

Figure 3.4: Range of Methodologies in Research Paradigms



Source: (Healy and Perry, 2000)

Table 3.2: A Framework for Research Methods in Operations Management



Source: (Meredith, et al. 1989)

Other authors (Pannirselvam, et al. 1999) also study the research methods in operations management. They find that modelling and simulation dominate

operations management research, whilst case studies only represent 4.61% of the operations management research studied.

3.2.4 Evaluation of Research Paradigms Discussion

Epistemology concerns with what is acceptable knowledge in a field of study (Saunders, et al. 2007). Realism is an epistemological position which relates to scientific enquiry. Saunders et al. (2007) argue that the critical realists' position is that the social world is constantly changing, thus to understand the reason for phenomena is a precursor to recommending change. The thesis uses this aspect of realism, since it aims to develop a methodology, first through understanding the world of risk in the aerospace industry.

One could go on to argue that interpretivism also could be the underpinning of the thesis since this epistemology advocates that it is necessary for the researcher to understand the differences between humans in our role as social actors (Saunders, et al. 2007). Thus, the research was conducted between people rather than objects such as computers or cars. In reality the paradigm of the thesis can be seen to be realist according to table 3.2. One could argue that realism and interpretivism have an argument to be the underpinnings of the thesis, since the focus is on social interactions.

Ontology is concerned with the nature of reality (Saunders, et al. 2007). The ontology of realism which argues that reality is real but only imperfectly and probabilistically apprehensible can be seen in the PhD.

3.2.5 Comparison of Qualitative and Quantitative Research Designs

Realist research and interpretivist research focuses on the qualitative aspects of research (Healy and Perry, 2000). This thesis will argue that qualitative research can be used to support the epistemology and ontology of the realist paradigm which dominates the thesis's research paradigm. Qualitative research relates to non numerical data research or data that have not been quantified, whereas quantitative research is based on numerical data to data that have been quantified (Saunders, et al. 2007).

3.2.6 Qualitative Research

Case studies as identified by Yin (2002), criteria is different to the Realist criteria since it only mentions ontological issues in the definition of a case, but does not include them as the criteria of quality research (Healy and Perry, 2000). The thesis can use multiple case studies as depicted in Saunders, et al. (2007). The rationale for using multiple cases focuses on the need to establish whether or not the findings of the first case occur in other cases, and as a consequence, the ability to generalise from these findings. Qualitative research is often depicted as a research strategy whose emphasis on a relatively open-ended approach to the research process frequently produces surprises, changes of direction and new insights (Bryman, 2006). The richness of case study research can be further strengthened to assure maximum measurement reliability and theory validity through a number of steps (McCutcheon and Meredith, 1993). Which when done properly, case study research can be a truly scientific research approach (Meredith, 1998). As discussed earlier, Meredith et al. (1989) also argue that action research and case studies fall into the interpretive dimension see table 3.2.

3.2.7 Quantitative Research

Limitations of the case study include cost, time, inability to generalise and prescribe, and potential for bias in the perceptions of the researchers (Boyer and Swink, 2008). In quantitative data analysis, the imaginative application of techniques can result in new understandings. If the two are conducted in tandem, the potential – and perhaps the likelihood – of unanticipated outcomes are multiplied. Mixed-method research is a dynamic option for expanding the scope and improving the analytic power of studies (Sandelowski, 2000). Mixed methods use both quantitative and qualitative research methods. When done well, mixed-method studies dramatize the artfulness and versatility of research design. This research will use a multi method approach which is two different methods within qualitative research (Meijer et al., 2002). Thus clearly defined qualitative results would make the research more credible and help triangulate the findings. Miles and Huberman's (1994) research highlights five types of triangulation in qualitative research:

1. Triangulation by data source (data collected from different persons, or at different times, or from different places);
2. Triangulation by method (observation, interviews, documents, etc.);
3. Triangulation by researcher (comparable to interrater reliability in quantitative methods);
4. Triangulation by theory (using different theories, for example, to explain results);
5. Triangulation by data type (e.g., combining quantitative and qualitative data).

Triangulation by method is the approach that this thesis will use, using multi method qualitative research. Furthermore, the qualitative research could be more clearly defined in terms of the types of interviews conducted, i.e. structured, semi structured. The thesis thus will use exploratory semi structured interviews followed by focus

groups to improve the rigour and triangulation of the research as endorsed by Lambert and Loiseau (2008) from an investigation using focus groups and interviews.

3.2.8 Conclusion

This PhD's research paradigm seems to be balanced towards the realist paradigm; however the social network analysis aspect can lend itself more towards the interpretivist paradigm. In reality, the paradigm is probably in between the two, since they can be seen as a continuum of aspects. The methodologies used can be qualitative, i.e. use case studies and semi structured interviews, followed by focus groups to test the propositions.

3.2.9 Arguments For and Against Methods Chosen

Bryman and Burgess (1999) look at the contrasting dimensions of quantitative and qualitative research. Table 3.3 lists eight dimensions that the two research traditions diverge.

Table 3.3: Eight Dimensions of Research Traditions



Source: Bryman and Burgess (1999)

The initial research questions from the literature review naturally directed the methodology to be of an exploratory case study of the OEM. One argument for using only qualitative methods in this research was due to the excellent access available to the OEM organisation and its employees. Why use quantitative methods when a richer and in depth use of case study in detail could be used. Fifteen semi structured interviews in the OEM and its suppliers allowed the research to get the detail required that may not have been obtained through a questionnaire. This level of detail allowed the research to develop propositions, which had provenance in the OEM and also in the literature.

3.3 Inductive versus Deductive Research Approach

The inductive approach involves the development of theory as a result of the observation of empirical data. The deductive approach involves the testing of a theoretical proposition from existing theory (Saunders, et al. 2007). The approach to research was selected once the philosophy of the research was much clearer. Since the literature review identified the research themes and they were not based on any explicit theory that was apparent in the literature, deduction (testing theory) was ruled out as an avenue of research at this stage. Since the research was seen to be interpretivist and realist based, the approach of induction, building theory, was seen as a more appropriate approach for the research. Thus the research used qualitative data (Easterby-Smith et al., 2002) using a smaller sample than a deductive approach, and using multi method research tools to collect the data.

It is important for choosing the right research approach for three reasons (Easterby-Smith et al., 2002):

- Firstly, it enables the researcher to make an informed decision about the research design.
- Secondly, it helps choose the right research strategies. So understanding why something is happening versus what is happening indicates use of the inductive approach.
- Thirdly, knowledge of different research approaches enables one to adapt the research design to cater for constraints. These may include limited access to data or lack of prior knowledge of a subject to allow hypothesis building for deductive approaches.

This process seems to be suited to the aims of this thesis and the inductive approach was chosen to develop theory, as to understanding why and how disruption risk is identified in the supply chain of the OEM.

The following sections will analyse the literature review and choice of methodology strategy in more detail.

3.4 Literature Review Methods

A research process began by a literature review which was conducted to gather literature with regard to the initial research proposal. This was undertaken in three stages:

- Identification of research areas

- Selection of key strings and hit rates on search engines
- Identification of core literature

3.4.1 Identification of Relevant Areas of Research

Identification of research areas that will be relevant to the research aims identified in chapter one were found via a brainstorming session with the researcher of this thesis, a supervisor, Naomi Brookes and another doctoral researcher. These areas were identified as all encompassing the idea of risk and information management. This was followed up by identifying keywords that were relevant to the research areas. An initial search of the Proquest search engine using the terms supply chain risk, found further keywords for the main body of research. A number of search engines were then selected that could be used to identify the key citation indexes for the research. The keywords found were then assembled to create key strings that will be used in the search engines to cite relevant articles:

3.4.2 Key Areas That the Literature Aims to Look at

1. Supply chains
2. Aerospace supply chains
3. Supply chain management and strategy
4. Supply chain risk management. Risk information management
5. Information management and knowledge management
6. Industrial network theory
7. Industrial social/ informal networks
8. Social network analysis (excluding online social networks such as Facebook, Twitter etc.)

3.4.3 Keywords

Examples of keywords which were found via a brainstorming session, in relation to the research areas mentioned above, were:

reliability, resilience, uncertainty, robust*, redundancy, netchain, aerospace, supply chain, network*, complexity, risk, strategy, management, innovat*, SCOR, VSCOR, social, lean, diffusion, actors, mapping

3.4.4 Search Engines

The Business and Science databases in the library were used to search with key strings drawn from the above mentioned keywords. These databases were:

- EBSCO
- Emerald
- ISI Web of Science
- Proquest
- Science Direct
- Scopus
- Swetwise

Google scholar was also used as an open search engine to find scholarly articles that may have been missed from the search engines used above.

3.4.5 Key Strings and Hit Rate on Search Engines

The key strings were entered into all the search engines mentioned above and the numbers of hits were noted. These can be seen in appendix A. The top four databases were selected and then key strings were entered into these and the numbers of peer reviewed hits were noted. An example of some of the searches and hits can be seen in appendix A.

3.4.6 Selection of Studies

The selections of articles were decided by initially reading the abstracts of the articles found from the search engines. These articles were then read and summarised in chapter 2 by theme.

3.5 Case Study Background

An exploratory study is a valuable means of finding out what is happening to seek new insights; to ask questions and to assess phenomena in a new light (Robson, 2002.).

3.5.1 Detailed Case Study Design

In this research, case studies with multiple interviews, which are an appropriate way of establishing the field at the early stages of an emerging topic will be used (Eisenhardt, 1989). Yin (2002) has come up with a technical definition of a case study. First, the technical definition begins with the scope of a case study:

- A case study is an empirical inquiry that

- Investigates a contemporary phenomenon within its real-life context, especially when
- The boundaries between phenomenon and context are not clearly evident

However, because phenomenon and context are not always distinguishable in real-life situations, the definition includes a whole set of technical characteristics, including data collection and data analysis strategies:

- The case study enquiry
 - Copes with the technical distinctive situation in which there will be many more variables of interest than data points, and as one result
 - Relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
 - Benefits from the prior development of theoretical propositions to guide data collection and analysis

The development of theoretical propositions to guide data collection and analysis is used in this thesis. The literature review developed themes to research in the exploratory phase of the research. The findings from the exploratory phase helped develop propositions which were tested in the focus group phase of the research.

For case studies, five components of a research design are especially important, these are summarised in table 3.4, below:

Table 3.4: Five Components of Research Design



A list of commonly required skills is as follows, a good investigator must (Yin, 2002):

- Ask good questions, interpret the results
- Be a good listener and not be trapped by his or her own ideologies or preconceptions
- Be adaptive and flexible
- Have a firm grasp of the issues being studied
- Be unbiased by preconceived notions

During the case study, interviews and focus groups, all of these requirements were consciously followed by the interviewer. Some aspects of the above list, such as preconceived notions, and preconceptions, would be difficult to remove from this phase of research since the researcher of the thesis designed the questions from a review of the literature. If an independent interviewer was used for this phase these aspects may be removed, but this has to be balanced by would the interviewer have a firm grasp of the issues being studied.

The sources of evidence in a case study can include: documentation, archival records, interviews, direct observations, participant observation, and physical artefacts. One of the most important sources of case study information is the interview. Throughout the interview process, you have two jobs (Yin, 2002):

- To follow the line of inquiry, as reflected by your case study protocol
- To ask your questions in an unbiased manner that also serves the needs of your line of inquiry

The research that has been conducted not only includes data collection via interviews, but also data collection via documentation, secondary data, and participant observation.

3.5.2 Problems and Limitations

One of the main problems or limitations with using one main case within the OEM is the generalisability of the findings. This is often referred to as external validity and is the extent to which the results of research are generalisable, that is whether the findings can be applicable to other research settings, such as other organisations or industries. The issues around the generalisability will be discussed later in this

chapter and in the conclusions in chapter 7. The potential problem of this lack of generalisability can be helped by conducting the two supplementary cases in the supply chain of the OEM. These two organisations although supplying the OEM, were not aerospace organisations. One was an electronics supplier and the other a bearings manufacturer. They supply other organisations and industries other than the OEM. Thus the case studies used in their organisations would help improve the generalisability of the main case study, as the same questions and interview techniques were applied to the two supplementary cases as with the main case.

3.6 Interview Methods

This approach was used to investigate the OEM via the use of semi structured interviews. The seven stages of analysis are shown in table 3.5

This table provided a good framework for the methodology of the case study interview process. The process of analysing and verifying the data will be discussed later in the chapter. The design of the interview process began with choosing a suitable sample for interview; this will be discussed in the following sections:

Table 3.5: Seven Stages of Interview Analysis

Stage	Analysis	Explanation
1	Thematizing.	Formulate the purpose of an investigation and describe the concept of the topic to be investigated before the interview starts. This was done at the outset of the investigation. The why and what of the investigation should be clarified before the question of the how method is posed.
2	Designing.	Plan the design of the study, before the interviewing starts.
3	Interviewing	Conduct the interviews based on an interview guide and with a reflective approach to the knowledge sought and the interpersonal relation of the interview situation.
4	Transcribing.	Prepare the interview material for analysis, which commonly includes a transcription from oral speech to written text. This was done in handwritten format first, and then typed.
5	Analyzing.	Decide, on the basis of the purpose and topic of the investigation, and on the nature of interview material, which methods of analysis are appropriate for the interviews. The transcripts were coded via a software application called QSR Nvivo. A course on Nvivo was attended by the researcher.
6	Verifying.	Ascertain the generalizability, reliability, and validity of the interview findings. Reliability refers to how consistent the results are, and validity means whether an interview study investigates what it intended to be investigated.
7	Reporting.	Communicate the findings of the study and the methods applied in a form that lives up to scientific criteria.

Source: adapted from Kvale, 1996.

3.6.1 Interview Sampling Strategy

A key informant strategy and a snowballing strategy were used to select the samples for the interviews at the OEM (Miles and Huberman, 1994.). These strategies support the method of theory building as described by Miles and Huberman, (1994). This was particular important to this research since the interviews were at an exploratory stage of the research. Key informants and snowballing identifies cases of interest from people who know people who know that they are suitable for similar lines on questioning around the research framework. The initial sample was provided by the Managing Director of the OEM who was the “key informant” (Miles and Huberman, 1994.). Then each interviewee was asked towards the end of the interview whom they may think would be suitable for a similar interview and who may be knowledgeable of the kind of questions asked. The focus groups attendees were also selected based on key informants, namely, the Head of Purchasing in the OEM, and the Group Convenor at the University.

3.6.2 Interview Sample Composition

The sample of interviewees in the exploratory case study and focus group attendees are listed in the following table 3.6

Table 3.6: Interview Sample Composition

Interviews	Focus Group One	Focus Group Two	Focus Group Three	Focus Group Four
Demand Planner*	Vice-President Procurement	Senior Buyer (Supply)	Teaching Fellow O&IM	Lecturer O&IM
Senior Buyer (Sourcing)*	Senior Buyer (Supply)	Team Leader (Supply)	Professor O&IM	Reader O&IM
Senior Purchasing Manager*	Senior Buyer (Supply)	Senior Buyer (Sourcing)	First Year PhD Student O&IM	Senior Lecturer O&IM
Senior Buyer (Supply)*	Senior Buyer (Sourcing)	Buyer (Supply)	First Year PhD Student O&IM	Lecturer O&IM
Head of Purchasing	Sourcing Engineer	Buyer (Supply)	First Year PhD Student O&IM	Group Convenor O&IM
Finance Manager	MRO materials manager	Senior Purchasing Manager	Final Year PhD Student O&IM	Head of Group O&IM
Head of Supply Chain	Demand Planner		Final Year PhD Student O&IM	Senior Lecturer O&IM
Managing Director				
MRO Manager				
Internal Purchasing Manager				
Supply Chain Manager				
Strategic Sourcing Manager				
Engineering Manager				

The roles followed by * in indicate the interviewees who also attended one of the focus groups.

There were five interviewees who also attended one of the OEM focus groups. Otherwise, the OEM focus groups were attended by people who were not aware of the initial interview phase of the research.

3.6.3 Types of Interview Questions

The exploratory interview questions were designed using the following approach (Kvale, 1996):

1. Introducing questions. Can you tell me about your experience of disruption risk in the organisation?
2. Follow up questions.
3. Probing questions. Could you say something more about that social networks in your organisation?
4. Specifying questions. What did you think then?
5. Direct questions.
6. Indirect questions.
7. Structuring questions.
8. Silence
9. Interpreting questions. Is it correct that you feel that?

Open ended questions were designed based on this analysis. The Introducing questions and probing questions can be seen in appendix B. The follow up questions and interpreting questions were based on interviewees responses to the introducing and probing questions.

3.6.4 Six Steps of Analysis

Kvale (1996) describes six steps of analysis, which were used to analyse the feedback from the interviews:

1. A first step is when subjects describe the lived world during the interview. They tell what they experience, feel, and do in relation to a topic.
2. A second step would be that the subjects themselves discover new relationships during the interview.
3. In a third step, the interviewer, during the interview, condenses and interprets the meaning of what the interviewee describes and sends the meaning back.
4. A fourth step, the transcribed interview is interpreted by the interviewer. This involves structuring the interview material for analysis, clarification of the material, and the analysis proper involves developing the meanings of the interview.
5. A fifth step would be to re-interview. This is an opportunity to clarify the original interview as well as comment on the interviewers interpretations of the interview. Focus Groups will be used to conduct this step.
6. A possible sixth would be to extend the continuum of description and interpretation to include action, in that subjects begin to act from new insights they have gained through interviewing.

The first five steps were conducted by the interviewer (steps 3, 4 and 5) and the interviewees (steps 1 and 2). Step 6 would be a process in which the interviewee would make changes to their existing thought or work processes through insights gained from the interviews. So an interviewee may, for example, decide that they may use their social networks more actively in identifying supply chain disruption risk.

3.7 Theoretical Saturation of Interviews

In the paper, "Sample Size and Saturation in PhD Studies Using Qualitative Interviews", Mason (2010) argues that a number of issues can affect sample size in qualitative research; however, the guiding principle should be the concept of saturation.

Samples for qualitative studies are generally much smaller than those used in quantitative studies. Mason (2010) argues that there is a point of diminishing return to a qualitative sample - as the study goes on more data does not necessarily lead to more information. This is because one occurrence of a piece of data, or a code, is all that is necessary to ensure that it becomes part of the analysis framework. Frequencies are rarely important in qualitative research, as one occurrence of the data is potentially as useful as many in understanding the process behind a topic. This is because qualitative research is concerned with meaning and not making generalised hypothesis statements (see also Crouch and McKenzie, 2006). Finally, because qualitative research is very labour intensive, analysing a large sample can be time consuming and often simply impractical. If a researcher remains faithful to the principles of qualitative research, Mason (2010) argues that sample size in the majority of qualitative studies should generally follow the concept of saturation when the collection of new data does not shed any further light on the issue under investigation.

Mason (2010) goes on to argue that while saturation determines the majority of qualitative sample size, other factors that can dictate how quickly or slowly this is achieved in a qualitative study. Charmaz (2006) suggests that the aims of the study are the ultimate driver of the project design, and therefore the sample size. She

suggests that a small study with "modest claims" might achieve saturation quicker than a study that is aiming to describe a process that spans disciplines.

Other researchers have also found further factors that can influence a qualitative sample size, and therefore saturation in qualitative studies. Ritchie et al. (2003) outlines seven factors that might affect the potential size of a sample:

1. The heterogeneity of the population;
2. The number of selection criteria;
3. The extent to which 'nesting' of criteria is needed;
4. Groups of special interest that requires intensive study;
5. Multiple samples within one study;
6. Types of data collection methods use;
7. The budget and resources available.

The exploratory case study at the OEM and suppliers was restricted to 15 interviews because of the resources available in terms of the number of potential interviewees in the OEM who had supply chain interaction experience. Saturation was not below the fifteen interviews since new findings, such as triggers for disruption risk, were different from different interviewees' experiences. Saturation was at 15 interviews since the interviewees experiences began to produce similar results, such as in their acknowledgment of the importance of social networks for identifying disruption risk.

Mason (2010) found that a large proportion of the samples of PhD studies (80%) adhered to guidelines of 15 being the smallest number of participants for a qualitative study irrespective of the methodology. Mason goes on to agree that saturation is achieved at a comparatively low qualitative sample size.

Mason (2010) findings were that:

- On the one hand, PhD researchers (and/or their supervisors) don't really understand the concept of saturation and are doing a comparatively large number of interviews. This ensures that their sample sizes, and therefore their data, are defensible.
- Alternatively PhD researchers do understand the concept of saturation but they find it easier to submit theses based on larger samples than are needed "just to be on the safe side" (and therefore feel more confident when it comes to their examination).
- Irrespective of their understanding of saturation, PhD researchers are using samples in line with their proposal to suit an independent quality assurance process (i.e. doing what they said they were going to do).

According to Mason (2010) the common sample sizes and the preference for a certain "type" of approach suggest something preconceived about the nature of the PhD studies analysed here. The question that derives from this are students completing their samples based on what they feel they can defend, and what their supervisors and institutions require, rather than when they feel their work is actually complete?

3.8 Analytic Strategy in Case Studies

The strategy will help to use tools and make manipulations more effectively and efficiently (Yin, 2002). Three such strategies are described below. A continued alert is to be aware of these strategies before collecting your data, so that you can be sure that the data will be analyzable.

- Relying on theoretical propositions
- Thinking about rival explanations
- Developing a case description

The best preparation for conducting case study analysis is to have an analytic strategy or themes to explore in the case study. This was done before the exploratory case study was conducted, and before the multiple case studies were attempted. Themes to explore were developed (chapter 2) which were tested in the exploratory case study (chapter 4). These were then developed into propositions to be tested via focus groups (chapter 5).

The following sections look at the theory behind focus groups in more detail. It looks at Gibbs' (1997), McNamara's (2006), Rabiee's (2004) and Kreuger's (1994) research in particular.

3.9 Focus Groups

Gibbs' (1997) online article arises out of a review of focus group methodology conducted for the Department of Social Medicine at Bristol University in March 1997.

She summarises the use of focus groups in the following:

- Focus group research involves organised discussion with a selected group of individuals to gain information about their views and experiences of a topic.
- Focus group interviewing is particularly suited for obtaining several perspectives about the same topic.

- The benefits of focus group research include gaining insights into people's shared understandings of everyday life and the ways in which individuals are influenced by others in a group situation.
- Problems arise when attempting to identify the individual view from the group view, as well as in the practical arrangements for conducting focus groups.
- The role of the moderator is very significant. Good levels of group leadership and interpersonal skill are required to moderate a group successfully.

Focus groups are under-used in social research, although they have a long history in market research (Morgan 1997, Kreuger 1994), and more recently in medical research (Powell and Single 1996). This paper by Gibbs (1997) examines the value of focus groups as a tool for social researchers and considers their potential and their limitations.

3.9.1 What are Focus Groups?

There are many definitions of a focus group in the literature, but features like organised discussion (Kitzinger 1994), and interaction (Kitzinger 1995), group interview (Morgan 1997) identify the contribution that focus groups make to social research.

Kreuger (1994) defines a focus group as a special type of group in terms of purpose, size, composition and procedures. A focus group is typically composed of 7 to 10 participants who are selected because they have certain characteristics in common that relate to the topic of the focus group.

3.9.2 The Use of Focus Groups Compared to Other Methods

Gibbs (1997) argues that the main purpose of focus group research is to draw upon respondents' attitudes, feelings, beliefs, experiences and reactions (Kreuger, 1994.) in a way in which would not be feasible using other methods, for example observation, one-to-one interviewing, or questionnaire surveys (Kreuger, 1994). These were the primary reasons for choosing focus groups to test the theoretical propositions developed from the initial exploratory case study. These attitudes, feelings and beliefs may be partially independent of a group or its social setting, but are more likely to be revealed via the social gathering and the interaction in which being in a focus group entails. Compared to individual interviews, which aim to obtain individual attitudes, beliefs and feelings, focus groups elicit a multiplicity of views and emotional processes within a group context. The individual interview is easier for the researcher to control than a focus group in which participants may take the initiative. Gibbs (1997) argues that compared to observation, a focus group enables the researcher to gain a larger amount of information in a shorter period of time. Barbour and Kitzinger (1999) describes the importance, in their research, of combining focus groups with individual interviews.

3.9.3 The Role of Focus groups

Gibbs (1997) argues that focus groups can be used at the preliminary or exploratory stages of a study (Kreuger 1994); during a study, perhaps to evaluate or develop a particular programme of activities (Race, et al. 1994); or after a programme has been completed, to assess its impact or to generate further avenues of research, as was the case in this research. They can be used either as a method in their own right or

as a complement to other methods, especially for triangulation (Morgan 1997, Kreuger 1994) and validity checking. Multi-method types of research uses focus groups typically add to the data that are gathered through other qualitative methods such as participant observation and individual interviews. This is the approach that this thesis has used.

3.9.4 Potential and Limitations

Kreuger (1994) argues that focus groups can be used alone, independent of other procedures; they are helpful when insights, perceptions and explanations are more important than actual numbers. Kreuger (1994) argues that focus groups are a socially orientated research procedure, since people are social creatures who interact with each other. The format of focus groups also allows the moderator to probe. The focus group also has high face validity, the technique is easily understood and the results are believable to those using the information. Results are not presented in complicated statistical charts but in lay terminology with quotations from group participants. Focus groups are relatively low cost and can provide speedy results. Another advantage being focus groups enable the researcher to increase the sample size of qualitative studies.

Kreuger (1994) argues that qualitative approaches such as focus groups or individual interviews enable the researcher to get in tune with the respondent and discover how the person sees reality. Another advantage of focus groups to clients, users, participants or consumers is that they can become a forum for change (Race et al. 1994), both during the focus group meeting itself and afterwards.

3.9.5 The Organisation of Focus Groups

Organising focus group interviews usually requires more planning than other types of interviewing as getting people to group gatherings can be difficult and setting up appropriate venues with adequate recording facilities requires a lot of time.

The recommended number of people per group is usually six to ten Gibbs (1997). Numbers of groups vary, some studies using only one meeting with each of several focus groups (Burgess 1996), others meeting the same group several times. Focus group sessions usually last from one to two hours. Neutral locations can be helpful for avoiding either negative or positive associations with a particular site or building (Powell and Single 1996). Otherwise the focus group meetings can be held in a variety of places, for example, people's homes, in rented facilities, or where the participants hold their regular meetings if they are a pre-existing group. This is where the focus groups were held in this research in meeting rooms in which the attendees were familiar.

It is not always easy to identify the most appropriate participants for a focus group. If a group is too heterogeneous, whether in terms of gender or class, or in terms of professional and 'lay' perspectives, the differences between participants can make a considerable impact on their contributions. Alternatively, if a group is homogenous with regard to specific characteristics, diverse opinions and experiences may not be revealed. Participants need to feel comfortable with each other. Meeting with others whom they think of as possessing similar characteristics or levels of understanding about a given topic, will be more appealing than meeting with those who are perceived to be different (Morgan 1997). Kreuger, 1994, argues that focus groups are best conducted with participants who are similar to each other, and this homogeneity is reinforced in the introduction to the group discussion. The focus

groups in this research were thus conducted with attendees who were familiar to each other.

Once the types of participant have been decided, locating them is the next challenge. Recruitment of participants can be time consuming, especially if the topic under consideration has no immediate benefits or attractions to participants. It is likely that people with specific interests will have to be recruited by word of mouth (Burgess 1996), through the use of key informants, by advertising or poster campaigns (Gibbs, 1997), or through existing social networks. A key informant namely the Purchasing Manager in the OEM helped recruit the attendees in the OEM, whilst the attendees were recruited in the academic setting through the Operations and Information Management Group Convener.

3.9.6 The Role of the Moderator

Once a meeting has been arranged, the role of moderator or group facilitator becomes critical, especially in terms of providing clear explanations of the purpose of the group, helping people feel at ease, and facilitating interaction between group members. Prof. Naomi Brookes was the moderator in the two focus groups in the OEM. The author of this thesis observed the focus group and took detailed notes of the discussion. The author of this thesis was the moderator in the two focus groups in the University. Naomi had left the University so the author of this thesis was required to moderate the groups and take notes also. The consistency of the moderation was maintained since the same materials were presented to both sets of groups, and the initial notes for the preparation for the first two focus groups were used to prepare for the second two focus groups.

During the meeting moderators will need to promote debate, perhaps by asking open questions. They may also need to challenge participants, especially to draw out people's differences, and tease out a diverse range of meanings on the topic under discussion. Sometimes moderators will need to probe for details, or move things forward when the conversation is drifting or has reached a minor conclusion. Moderators also have to keep the session focused and so sometimes they may deliberately have to steer the conversation back on course. Moderators also have to ensure everyone participates and gets a chance to speak. At the same time moderators are encouraged not to show too much approval (Kreuger 1994), so as to avoid favouring particular participants. They must avoid giving personal opinions so as not to influence participants towards any particular position or opinion.

The role of the moderator is a demanding and challenging one, and moderators will need to possess good interpersonal skills and personal qualities, being good listeners, non-judgmental and adaptable. These qualities will promote the participants' trust in the moderator and increase the likelihood of open, interactive dialogue.

Finally, the degree of control and direction imposed by moderators will depend upon the goals of the research as well as on their preferred style. If two or more moderators are involved in the facilitation of a focus group, agreement needs to be reached as to how much input or direction each will give. It is recommended that one moderator facilitates and the other takes notes and checks the recording equipment during the meeting. There also needs to be consistency across focus groups, so careful preparation with regard to role and responsibilities is required.

3.10 Focus Groups Summary

The main features of focus group research have been explored, paying particular attention to the benefits of interaction and group dynamics which only this method can offer. The process of research can be more collaborative than other forms of study, and so focus group research can be an empowering process for participants and an exciting challenge for social researchers wanting to gain a different perspective on their field of interest.

Four focus groups were conducted in total. Two were conducted at the OEM, with seven members and six members of the organisation in each. Two were conducted in the University, with seven invited academics attending each one. A frequently-asked question is about the number of focus groups. Kreuger (1994) suggests continuing with running focus groups until a clear pattern emerges and subsequent groups produce only repetitious information (theoretical saturation). However, several authors, including Kreuger (1994), suggest that for a simple research question the number of focus groups necessary may only be three or four.

Kreuger (1994) argues that in focus groups interviews, the first two groups provide a considerable amount of information, but by the third or fourth session a fair amount has already been covered. The use and appropriateness of using four focus groups for a study, is endorsed by Calder (1977). Morgan (1997) argues that the goal is to do only as many groups as required to provide a trustworthy answer to the research question due to the limitations and costs involved in conducting more groups. Numbers of groups vary, some studies using only one meeting with each of several focus groups (Burgess 1996), so supports the use of four focus groups with one meeting for each one.

Similar questions were put to the focus groups, as were put to the exploratory interviews, as based on Kreuger's (1994) research. The focus group studies were also electronically recorded and the transcripts thematically analysed using Nvivo 2.0 and Nvivo 8.0.

Meeting with others whom they think of as possessing similar characteristics or levels of understanding about a given topic, will be more appealing than meeting with those who are perceived to be different (Morgan 1997). This also backs the use of two OEM focus groups and two academic focus groups. It is likely that people with specific interests will have to be recruited (Burgess 1996), through the use of key informants, hence the OEM focus group participants were recruited through the Purchasing Manager and the University participants through the Operations and Information Group Convener.

Gibbs (1997) argues that during the meeting moderators will need to promote debate, perhaps by asking open questions. They may also need to challenge participants, especially to draw out people's differences, and tease out a diverse range of meanings on the topic under discussion. The role of the moderator is a demanding and challenging one, and moderators will need to possess good interpersonal skills and personal qualities, being good listeners, non-judgmental and adaptable. All these principles were followed by the research. Gibbs (1997) also argues that there also needs to be consistency across focus groups, so the same material and preparation was used for all focus groups.

Webb and Kevern (2001) proposed that the vast majority of focus group research appears to use thematic analysis. This method was deemed appropriate for this research. The printed discussion was read and reread and coded for recurring regularities.

3.11 Focus Group and Interview Analysis

3.11.1 Analysis Choices

Kreuger's (2011) online article summarises the different analysis types and more importantly the perceived level of rigour attached to each. These can be seen in table 3.7

Table 3.7: Table of Analysis Types



Source: Kreuger Analysis Choices (2011),

http://www.tc.umn.edu/~rKreuger/focus_analysis.html

Transcript based analysis takes the longest time to complete analysis but the level of rigour is high and the risk of error is low. This is what this thesis used. The interviews and focus groups were transcribed into Microsoft Word.

Focus groups can generate large amounts of very rich and dynamic data (Barbour and Kitzinger, 1999.). Rabiee (2004) looks at the analysis of focus groups in particular. There are a number of approaches to the analysis of qualitative data. This research uses Kreuger's (1994) framework analysis, but also incorporates some key stages of 'framework analysis' described by Ritchie and Spencer (1994). The advantage of the Kreuger (1994) approach is that it provides a clear series of systematic steps, which could help first-time researchers to manage the large amount and complex nature of qualitative data much more easily.

3.11.2 Coding

Unlike quantitative analysis, qualitative analysis, particularly focus-group analysis, occurs concurrently with data collection. Kreuger (1994) suggests that a helpful way of thinking about this role is to consider a continuum of analysis ranging from the mere accumulation of raw data to the interpretation of data: the analysis continuum: raw data; descriptive statements; interpretation.

It is important to point out that analysis does not take place in a linear form and that one part of the process overlaps another. 'Framework analysis' as described by Ritchie and Spencer (1994), is 'an analytical process which involves a number of distinct though highly interconnected stages'.

The five key stages outlined are: familiarization; identifying a thematic framework; indexing; charting; mapping and interpretation. The other distinctive aspect of framework analysis is that although it uses a thematic approach it allows themes to develop both from the research questions and from the narratives of research participants.

The process of data analysis begins during the data collection, by skilfully facilitating the discussion and generating rich data from the interview, complementing them with the observational notes and typing the recorded information. This stage is followed by familiarisation with the data, which can be achieved by listening to recordings, reading the transcripts in their entirety several times and reading the observational notes taken during interview and summary notes written immediately after the interview.

The aim is to immerse in the details and get a sense of the interview as a whole before breaking it into parts. During this process the major themes begin to emerge. The next stage involves identifying a thematic framework (see table 3.8), by writing memos in the margin of the text in the form of short phrases, ideas or concepts arising from the texts and beginning to develop categories. At this stage descriptive statements are formed and an analysis is carried out on the data under the questioning route. The third stage, indexing, comprises sifting the data, highlighting and sorting out quotes and making comparisons both within and between cases. The fourth stage, charting, involves lifting the quotes from their original context and re-arranging them under the newly-developed themes. Indexing and charting could also be viewed as managing the data. One of the most important aspects of this task is data reduction, which is achieved by comparing and contrasting data and cutting and pasting similar quotes together.

The data is now ready for the final stage of analysis, i.e. mapping and interpreting. One of the tasks here is not only to make sense of the individual quotes, but also to be imaginative and analytical enough to see the relationship between the quotes, and the links between the data as a whole.

The analysis of the interviews and focus groups thus allowed themes to develop from the research questions (chapter 2) and narratives of the interviewees or participants of focus groups.

Step One. The transcripts were analysed on paper first, and a code or themes were put next to each section of narrative.

Step Two. Each of these narratives were then coded into Nvivo until all of the transcripts and narratives had been analysed. The narratives within themes were then read and analysed to see if the codes could be broken down into further codes. However since the initial codes were detailed and distinct this was not deemed as necessary.

Step Three. Reports were then generated by theme, so that all conversations relating to a theme were under one heading. Please see appendix E and F, for an example of a coded interview and a theme and the related coded text from Nvivo.

The themes that were developed from the interviews with example text from one supply chain interview are listed in table 3.8:

Table 3.8: Table of Themes

Themes	Example text from Supply Chain Interview
1. Retrospective Study and OEM's Social Contacts	With the retrospective study we were semi-tipped off only days in advance; before they advised us that there was a problem and do we need to do something.
2. Retrospective Study Risk Triggers	For example with retrospective study, we are still waiting for an approval on alternate supply so our ability to switch to other commodities is heavily restricted compared to commercial non-aerospace markets.
3. Retrospective Study Situation	
4. Are OEM's Social Contacts Sufficient	I think we have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based so they have a UK representative.
5. Contacts in Supplier Companies	Personally, I haven't but our buyer would have built relationships with the companies involved. With XYZ we have built a working relationship over the past two years and I hope some form of friendship is formed here through phone calls. With ABC, none at all. What we do is deal with representatives one step removed from manufacturing and they are not a strong enough power within the company involved.
6. Contacts to Interview at OEM	
7. Current Process of Risk Identification and Mitigation	
8. Current Risks in Supply Chain	There is a key risk in the rush to outsource to developing economies potentially affecting our supply base. An example might be if we have a supplier who is wholly dependent on one customer who then outsources to China; the whole of that business may go under. If we chose to outsource one or our parts to China, we may enforce the closure of that company, even the parts we didn't want to outsource.
9. OEM's Initial Knowledge of Retrospective Study Situation	
10. How OEM Can Improve Social Networks with Suppliers	
11. How Far Down Supply Chain Do We Need To Manage Risk	I think it would be quite difficult to extend it beyond the first tier. Maybe the way is to encourage the supplier to do a similar type of exercise.

12. How Long Current Risks Will Take to Mitigate	
13. Is Aerospace Industry More Vulnerable to Risk Than Other Industries	
14. Is Risk Increased as You Outsource	The reality is it's a shared problem. I think you do lose more contact to see the risk as the more you outsource.
15. Are Social Contacts a Good Way of Identifying Risk	
16. Managing Obsolescence	
17. Problems of Sharing Information	We don't encourage too much contact on the social side due to general ethics policy because everything needs to be kept on a reasonable business level. If a buyer spends all his time lunching with a supplier there could be questions asked. So how do you set the balance so there is a trade off between ethics policy and social networks.
18. Push/Pull Information Flows	
19. Raw Materials - China Market Effect	
20. Solutions to Mitigate Risk	Maybe we should have a supplier forum which is more than just a price exercise, but actually how well the business is going. What we should be thinking about is having a health check visit with critical suppliers to see how well they are operating.
21. Triggers to Identify Risk on Horizon	

3.13 Ethical Issues

Ethical issues are relevant to all stages of focus group research design, implementation and presentation (Barbour and Kitzinger, 1999.). Gibbs (1997) argues that the ethical considerations for focus groups are the same as for most other methods of social research (Homan, 1991). For example, when selecting and involving participants, researchers must ensure that full information about the purpose and uses of participants' contributions is given. Being honest and keeping participants informed about the expectations of the group and topic, and not

pressurising participants to speak is good practice. A particular ethical issue to consider in the case of focus groups is the handling of sensitive material and confidentiality given that there will always be more than one participant in the group. At the outset moderators will need to clarify that each participant's contributions will be shared with the others in the group as well as with the moderator. Participants need to be encouraged to keep confidential what they hear during the meeting and researchers have the responsibility to anonymise data from the group. An informed consent statement was read to participants before the interviews and focus groups. This can be seen in appendix D.

3.14 Generalisability, Reliability and Validity

Reliability refers to how consistent the results are, and validity means whether an interview study investigates what it intended to be investigated (Yin, 2003). Generalisability is to what extent the findings of research can be generalised in another research setting. These three aspects will be discussed below, and also in regards to the research process and findings of this thesis in the conclusions in chapter 7.

3.14.1 Reliability

Reliability can be assessed by posing the following three questions (Easterby-Smith et al, 2002):

1. Will the measures yield the same results on other occasions
2. Will similar observations be reached by other observers
3. Is there transparency in how sense was made from the raw data

Robson (2002) argues there may be four threats to reliability:

1. Subject or participant error. Information may be different based on time of day, or closeness to events happening in the workplace, i.e. if a risk has just been identified; the interviewee will base his interview on current events.
2. Subject or participant bias. Interviewees can be saying what they think the researcher or manager wants to hear.
3. Observer error. There can be more than one way of asking a question, and each way will spur different answers.
4. Observer bias. There are different ways of interpreting the replies from an interviewee.

The reliability of the data analysis was improved by using a method of inter-rater reliability testing. Inter rater reliability is the extent to which two or more individuals (coders or raters) agree (Voss, et al., 2002). The transcript was read by another researcher in the university, alongside the codes or themes, to see whether they agreed with the coding of the transcripts, which they did. The coding of the transcripts was tested this way so that the themes generated from the interviews and focus groups were shared and whether multiple coders can apply the same codes or themes (Ryan and Bernard, 2000). This process improved the reliability of the analysis stages.

3.14.2 Validity

Validity is concerned with whether the findings are really what they appear to be. Kreuger, 1994, argues focus groups are valid if they are used carefully for a problem that is suitable for focus group inquiry. He continues to point out that focus groups are very much like other social science measurement procedures in which validity

depends not only on the procedures used but also on context. Limitations of the case study include cost, time, inability to generalise and prescribe, and potential for bias in the perceptions of the researchers (Boyer and Swink, 2008).

3.14.3 Generalisability

This is often referred to as external validity and is the extent to which the results of research are generalisable, that is whether the findings can be applicable to other research settings, such as other organisations or industries. Stewart and Shandasini, 1990, argue there are limitations on the generalisability of focus groups, thus when recruiting candidates to be in the focus group convenience sampling can be used. Gibbs (1997) supports this and says focus groups are however limited in terms of their ability to generalise findings to a whole population, mainly because of the small numbers of people participating and the likelihood that the participants will not be a representative sample.

3.15 Chapter Summary

The methodology of this thesis has been developed in this chapter, which will expand the themes mentioned in the previous chapter into propositions. The main way to do this was through an exploratory case study in the OEM followed by cases within the supply chain of the OEM. This was done via the use of semi structured interviews. The findings of the exploratory case studies (chapter four) will develop the research themes into propositions and be further explored in chapter 5.

The propositions of this thesis will be further tested by the means of focus groups within the OEM and an academic setting. The OEM management wanted expert

opinion on the findings of the research so the Operations and Information Management Group members of Aston University were the members of the focus groups conducted in an academic setting. This combined with the OEM focus groups, meant that the basis of the testing of the propositions was not only practitioner based but also academically based. Since the themes of the research were also related to information management flows and social interaction, focus groups were a good method to use to analyse the propositions through group discussion.

Chapter Four – Findings of Exploratory Case Study

4.0 Introduction

An exploratory case study was conducted in the OEM through the use of semi structured interviews as detailed in the previous chapter. The individuals in the OEM were asked six questions in the semi structured interviews (see appendix B). They were asked as to what types of risks they perceived their organisation to be facing currently, the importance of social networks with regards to disruption risks, the triggers that they have experienced that first identifies disruption risk, and their views of social networks in general. This chapter will explore the findings of this case study through the means of themes and quotations from interviewees.

The case studies in the OEM's suppliers will be explored with regards to the risk perceptions of the OEM and suppliers. Each theme or section has an explanation of the findings followed by a quotation from the themes to justify the findings. The bold quotations refer to comments made by the interviewer.

4.1 Types of Risk

The literature review found many risks that organisations face, Ellis et al. (2009) summarise the perspectives of risk in relation to supply chain disruption as:

1. Technological uncertainty - the rate of change in underlying technologies of a purchased product
2. Market thinness - the degree to which a buying firm has [a limited number of] alternative sources of supply to meet a need

3. Item customization – the extent to which purchased items are modified according to the specifications of a specific buyer
4. Item importance - degree to which a purchased part is critical to the manufacture of an organization's other parts, components, or end-products
5. Search for alternative source of supply
6. Exogenous correlations

The literature does show that each organisation has its own perspectives on disruption risks, which will differ from individual to individual and organisation to organisation.

When asked about which types of risk that the OEM faced, the respondents listed the following risks:

1. Increased raw material prices
2. Raw material availability, due to pull from developing countries, e.g. China
3. Growth and capacity related risks, lead to increased lead times
4. Obsolescence risks, e.g. electronics that may no longer be available
5. Sole sourced products, particularly when design authority held by supplier
6. Environmental risks, e.g. flooding that can cause the shutdown of a supplier

Risk identification is the fundamental stage of the entire risk management process. The backbone of this process is based upon the monitoring of various key performance indicators (KPIs) related to the performance of supply chain partners. The level of an in-stock inventory, production throughput, capacity utilization and delivery lead times are some of the KPIs that can be used to identify an abnormal situation that may involve a potential risk (Giannakis, et al., 2011). However other

triggers may also identify when a risk is on the horizon, by exploring the behavioural indicators of risk.

4.2 Behavioural Indicators of Risk

The interviewees were asked to suggest possible behavioural indicators or triggers that would identify risk in their supply chain. This line of enquiry was seeded in the literature where Sorensen (2005) argued that risk sources need to be identified. Sheffi (2005) mentions that the weakest signals need to be identified to reduce the likelihood of disruptions. Harland (2003) goes on to argue that the likelihood of a trigger that will realise a risk needs to be explored. The indicators that were suggested were as follows:

- Suppliers asking for changes to payment terms:

“If a supplier is asking for earlier payment terms, or chasing payment earlier than normal, it’s a good indicator that there is a cash flow problem.”
(Supply Chain)

- Late deliveries

“If deliveries tend to be late, that may be because they’re unable to pay their suppliers, so they haven’t got their raw materials.”
(Supply Chain)

- Unexpected price increases

“The risks are raw material prices and also things like utility prices. They have an adverse effect on costings and competitiveness.”
(Strategic Sourcing)

- Poor quality of parts

“It could be as simple as quality has begun to go wrong.”
(Supply Chain)

- Increased lead times

“Our lead times went out from nine months to twelve months.”

(Supply Chain)

- Staff turnover

“The other indicators are rapidly changing staff”

(Supply Chain)

When discussing the triggers of risk it was suggested that they will arrive from social communication flows from the salesmen in the supplier organisation, they would also be warning signs such as missing deliveries or requests for changes in payment terms:

“I think it tends to come from word of mouth from the contacts within the business i.e. our buyers dealing with their salesmen. The salesmen of your suppliers aren't going to be broadcasting the fact, but if you have got to have a good relationship then you ought to be finding those things out either by the grapevine or warning signs like they're missing deliveries or whatever, price increases or asking for special terms on payments. Pay at the end of the month instead of 30 days credit, those sorts of things would be the warning bells.”

(Finance)

It was also suggested that a trigger would be the regular findings from financial reports of the supplier organisation:

“The triggers tend to be identifying someone's financial state, for example using Dun and Bradstreet reports. The problem with them is they are a little while after the event; they can be useful for finding new suppliers. They tend to be backward looking, looking at previous years' results.”

(Supply Chain)

Because the triggers arrive at different points in time to different organisations, it was suggested a suite of indicators was needed to identify and therefore mitigate a risk on the horizon:

“I think what we need to think about is a suite of indicators. It could be as simple as deliveries are starting to lag or the quality has started to go down. It could be they started to chase payments earlier than they used to. All these things are fed to different individuals in an organisation and they don't see the overall picture. For example, if a supplier is asking for earlier

payment terms or chasing payment earlier than normal it's a good indicator there is a cash flow problem and it probably needs to be investigated further. If deliveries tend to be late that may be because they're unable to pay their suppliers so they haven't got their raw materials. Again, there's something fundamentally at risk in the business so we should be using the knowledge we have in terms of on time delivery, quality and performance; any information from anybody to get the general picture. The other indicators are rapidly changing staff, i.e. if a company has a high turnover of staff, particularly within management, that indicates there needs to be further investigation. I think that would be more than coincidental if a company has four MDs in a short period of time. I don't think that it is due to poor recruitment policy but there must be something more underlying than that, which would be a concern."

(Supply Chain)

It was further argued that the risk trigger information is a combination of social, financial and anecdotal. Also the supplier organisation may be unwilling to share risk information, which will also be discussed later.

"So there is a mixture of the social, financial and anecdotal. You could talk to others in the industry to see if there has been anything that they've heard. Generally if a company is in trouble they would work hard to make sure a supplier doesn't know because the first thing a supplier/customer would do is start to think about how to think of an alternate strategy."

(Supply Chain)

Deliveries going missing or late deliveries again were noted to be a problem:

"Worse case scenario, we send off a hitlist as this (product) should be in this week. I'll phone up where is it, and a lot of the time suppliers will let you go all the way, so there's no planning time."

(Purchasing)

One interviewee argued that because the OEM is at the end of the supply/customer chain they are the last to know if there is a risk on the horizon:

"Because we sit at the back we don't tend to see a lot of that (risk triggers) until it's actually happened!"

(MRO)

Changing lead times were seen as an important indicator that a risk was on the horizon, so increased lead times would indicate some level of risk or overcapacity issues were present in the supplier:

"It can be on lead time, a product you've had for years goes from 20 weeks to 56 weeks, you're aware there's a shortage out there."

(Purchasing)

"The other risk is material supplies, forge houses particularly where they have to buy the raw material from the mills and the lead times have been stretched out a long way. You may have to think about increased lead times – it's 90 weeks lead time on titanium, so our MRP systems have 32 week lead times that's manufacturing parts, but you can't supply it if the supplier hasn't got the raw material."

(Purchasing)

However, it was seen as a low level of risk as long as the OEM knows about the changes in lead time and also they can plan production as a result of changes in lead times:

"The triggers tend to be when lead times start to go out on forgings, that's the initial kick off. The long lead time tends to be related to forging. The lead time can be anything between 6 months and 15 months. That went up from a 6 month period, we don't see it as a risk, we need to react to it so on our system if we've got the correct lead time."

(Purchasing)

Unexpected price increases by suppliers of the OEM also pose a risk and would require further investigation in the supplier organisation:

"A price increase can generate a risk, if something's gone from £10 to £90 for example, you know there's one, a shortage of that part or two, they're in trouble themselves. You either say we've done well at getting the part at the current price or there's a problem out there with this part and you have to look a bit further."

(Purchasing)

Other triggers relate to social network information coming from supplier contacts as well as news made publicly available via the internet or published literature:

"There are other avenues such as hearing on the grapevine various problems and risks. And also on the internet or news; any major issues well published in the industry."

(Purchasing)

Keeping a close eye on the financial stability of a company; acquisitions and mergers and any changes in the industry.”

(Strategic Sourcing)

This can be further explored in terms of networking within industry bodies, from where information may be gleaned in terms of risk within the industry in general or within specific suppliers:

“Having your finger on the pulse, that would go to mitigating some risk. Certainly you mentioned networking earlier, we’re all at the professional side of the industry, members of various industry bodies. As a part of that we undertake a lot of networking with our professional institutes. That’s one way we can learn where the industries are going; where there may be a risk with certain suppliers. That’s networking within the industry bodies.”

(Strategic Sourcing)

All of the information regarding the behavioural indicators was currently available to the OEM. The triggers were being received into different departments of the organisation and to different individuals. However, no formal triggers for action to mitigate these risks from the behavioural indicators were in place.

4.2.1 Mapping Risks and Risk Triggers

In section 4.1 the following risks were identified by interviewees in the OEM.

1. Increased raw material prices
2. Raw material availability, due to pull from developing countries, e.g. China
3. Growth and capacity related risks, lead to increased lead times
4. Obsolescence risks, e.g. electronics that may no longer be available
5. Sole sourced products, particularly when design authority held by supplier
6. Environmental risks, e.g. flooding that can cause the shutdown of a supplier

This section has looked at the risk triggers that identify if there is a risk on the horizon. The risk triggers were seen as:

1. Suppliers asking for changes to payment terms:
2. Late deliveries
3. Unexpected price increases
4. Poor quality of parts
5. Increased lead times
6. Staff turnover

The table below, table 4.1, shows the possible relationships between risk triggers or indicators and the risk described by the interviewees.

Table 4.1: Table of Risks and Indicators

Indicator/ Trigger	Risk
1. Suppliers asking for changes to payment terms can indicate:	Increased raw material prices Raw material availability, due to pull from developing countries, e.g. China Growth and capacity related risks
2. Late deliveries can indicate:	Growth and capacity related risks, lead to increased lead times Obsolescence risks Environmental risks, e.g. flooding that can cause the shutdown of a supplier
3. Unexpected price increases can indicate:	Increased raw material prices Raw material availability, due to pull from developing countries, e.g. China Growth and capacity related risks
4. Poor quality of parts can indicate:	Growth and capacity related risks
5. Increased lead times can indicate:	Raw material availability Growth and capacity related risks
6. Staff turnover can indicate:	Financial difficulties due to: Any of the above risks.

From this analysis it can be seen that the risks that individuals argued that the OEM faced, and the triggers to risk that individuals faced in the OEM, are related and can be mapped.

4.3 Importance of Risk Identification Through Social Networks

Galaskiewicz (2011) looks at studying supply chains from a social network perspective, and suggests this can add value to the supply chain management literature. Furthermore, as found in the previous section, identifying risk through the organisations' social network was very important. This was consolidated by the views that social networks should extend beyond the first tier supplier in order to ascertain the types of risk that the OEM faced.

With respect to using social networks to identify and mitigate risk the people interviewed suggested that they are very important:

"It's based on hard facts...but we've got some good solid contacts, we've known for a long time."

(Purchasing)

"We've had to get closer to our suppliers, because we're a smaller size."

(Purchasing)

"Due to small size of organisation, social contacts are important".

(Supply Chain)

"The example with XYZ retrospective study, was we had no upfront knowledge it was going to happen and probably the only way of finding out about these things is through social networking, which is building a good relationship with suppliers so that they feel that they are obliged to let you know that a risk on the horizon, through a friendship basis."

(Supply Chain)

It can be seen from these quotes that the longevity of relationships with suppliers coupled with the small size of the OEM, means that social networks were seen to be important. Also good relationships with suppliers leads to trust formation through a friendship basis, so suppliers feel obliged to let the OEM know that there is a risk on the horizon.

4.3.1 Current Perceptions of Social Networks

The current perceptions of the social networks at the OEM were described as follows:

"I think that the contact and information is a good thing, but I think it needs to be formalised, not just a series of whispers from the grapevine."

(Finance)

"We have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based."

(Supply Chain)

We have "better contacts with customers than suppliers"

(Finance)

We are "not using social contacts when we could do"

(Supply Chain)

"What we ought to be thinking about is having a health check visit with critical suppliers, to see how well they're operating."

(Supply Chain)

"As things begin to get more and more global, it's (social contact) going to get more and more difficult."

(Purchasing)

The grapevine was used to describe the social networks between the OEM and its suppliers, and this needs to be formalised. The close proximity of suppliers leads to better social contact with suppliers as opposed to larger suppliers who have sales representatives as the point of contact for the OEM. However it was recognised that

social networks could be used better and that contacts with customers were still better than with suppliers.

4.3.2 Are the OEM's Social Contacts Sufficient

The perceptions of the social networks were further explored, and the levels of satisfaction of the interviewees with regard to their existing contacts or social networks were further questioned:

It was seen that the level of social networks were not as good as they could be.

"I don't think they're on as good as our contacts with customers, no! I'm not really that close to it to see how those links are."
(Finance)

The level of social contact and the locality of the supplier organisation also were seen as a factor:

"I think we have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based so they have a UK representative."
(Supply Chain)

Another interesting view was the importance of the social contact with regards to the riskiest supplier organisations:

"80/20 rule. 80% of suppliers we've got adequate contacts with, 20% of our suppliers which cause 80% of our problems, we don't."
(Purchasing)

Everyone has their own social contact networks, and the building of these social networks is based on the individual:

“Again, I’m trying to get most of mine, since I haven’t had the 10 years of working here and finding out who’s useful in this company and who’s not. I’d say most of the guys do get the contacts. I’ve got an interesting problem at the moment where all the people who work on in the area I deal with, are no longer here, so it’s the piecing together of things.”

(Purchasing)

“We would just drop in and build our own social network depending on the problem. We are looking at the supply chain at the moment. Just because of the role we are doing, we will create our social network as and when we drop into something.”

(Supply Chain)

“Everyone’s got their own network.”

(Supply Chain)

The small size of the OEM and also the long term standing of the organisation in terms of the production of parts meant that they have more social contacts with their supplier organisations, it also suggest that the social network constructs of size and diversity are limited:

“I think so, because we’ve been the smaller one of the wheel and brakes set up, we have been closer to our suppliers because we’re a smaller size.”

(Purchasing)

“(The OEM) has got a history with lots of the suppliers – 20, 30, 40 years. They still look at (The OEM) as one of their key people but we may not have such a great spend with them.”

(Purchasing)

Instrumental ties between the OEM and its suppliers were also suggested in the interviews with regard to the level of business. The level of business or spend with a supplier organisation, was also seen as a factor in terms of the social network:

“Some of our suppliers we do have a good spend with such as XYZ fairly good spend with, with ABC, not a massive spend with them but they’re a massive company we do have fairly good contacts.”

(Purchasing)

The regularity of contact between the supplier individuals and the OEM individuals was also argued to increase social contact:

“Well in my situation, out there is, there’s myself and the buyers classed as team leaders, they talk to the people on a regular basis. There’s a close relationship.”

(Purchasing)

“Yes, in this department there’s the manager and raw materials buyer who has been in the business for years, so they’ve obviously got good contacts. A lot depends on the commodity groups; each commodity group has its own contacts. I’d say yes, we are covered but not by one person, we rely on five or six people to pick up from their commodity group.”

(Purchasing)

This regularity suggests that there is stability in terms of the social network.

It was also seen that there are many relationships between the OEM individuals and the supplier organisation individuals, but whether these are the right types of relationships in terms of identifying risk, was questionable:

“There are very longstanding relationships whether they’re at the right level within the suppliers or our incumbent suppliers is questionable, especially when you’re looking at the stability of a company and where it’s going in its forward planning process.”

(Strategic Sourcing)

“Probably the relationships we’ve got with our suppliers are at a lower level in terms of buyer-sales person level. The solution is having the right intelligence with our buyers.”

(Strategic Sourcing)

One interviewee wasn’t sure about the sufficiency of social contact, but still agreed that there are social networks based on the regularity of contacts:

“Again where I’m placed its difficult for me to say that I don’t know enough about that here and how they deal with. There are certainly suppliers that I know about, historically you’d like to think yes because the guys are visiting quite regularly.”

(MRO)

To summarise, social contacts were generally seen as being sufficient and each individual in the OEM has their own social networks and take the initiative to build the social networks with suppliers. The nature of the organisation in terms of size, longevity, supplier spend, regularity of contact also leads to greater amount of contact with suppliers.

4.4 Contacts in Supplier Companies

The types of individual contacts with supplier organisations were also discussed, in relation to work based or social based. Galaskiewicz (2011) argues that there are weak ties, people who are seen as acquaintances, where social obligations are minimal. There are also strong ties, people who are seen as family or friends. Here social contact is stronger and reciprocated. The OEM individuals talk about this aspect of social networking in reference to individual contact:

“It’s, culturally, we don’t really do it, nobody goes on socials. It depends on the suppliers, but with the people who do would have been here a lot longer.”
(Purchasing)

“Only on a work basis.”
(Purchasing)

“At ABC my main contact has just left, whom I got on very well. We’d chat and also get a lot done. But he’s left. So I’m starting again with the next one. As it is all changed we’d probably visit them.”
(Purchasing)

It is therefore accepted within the OEM that socials or other forms of informal contact with suppliers is not the norm. Contact with suppliers is based on a work basis.

However, friendships and informal chats are present between individuals in the OEM and suppliers, and visits to suppliers on this basis do exist. These affective ties lead to moral ties which will be discussed later.

4.5 Current Process of Risk Identification and Mitigation

Understanding comprehensively what risk is, where risk exists, and how to mitigate risk definitely exhibits an additional research challenge in supply chain management (Tang and Nurmaya, 2011).

The risk management process is executed in four stages: risk identification, risk assessment, decision and implementation of risk management actions and optimization (Giannakis et al., 2011).

The current process of risk identification and mitigation in the OEM was seen as ad hoc, and not has any formal processes. The main process identified being financial checks on suppliers, but not routine or regular ones.

"I don't think there is any formal mechanism, not that I'm aware of here. No, I haven't come across any here."

(Strategic Sourcing)

"We do occasional exercises where when someone will come to me and ask for a D and B, a Dun and Bradstreet on this company. We tend to do that with a new supplier, if we were to get a new supplier on board, one of the things we would do is a D and B on that to find out their financial stability. We don't have a process that looks routinely for reviews of all of our supply base."

(Finance)

"A key branch of our supply base is on a check on the financial stability."

(Finance)

"One way of checking them out is if our finance guys did a D and B on them and on our key people on a regular basis that's one way of checking if the business is ok or not."

(Purchasing)

It was also argued that the OEM was last to know about risks, in particular related to raw materials:

“My gut feeling is, bearing in mind I’m removed from speaking to the raw materials people, but from the social networking and the people who work in those businesses they’ve been saying that we’re the last people to know - I’m talking in general about aerospace - what is actually required.”

(MRO)

Identifying risk through social networks was seen as important, but especially in relation to the methods of contact, i.e. direct over the phone, or via email.

“It’s once you’ve had that direct contact with them, I mean over the phone is a lot better than email, I think we’re in a society now where the email is taking over. I believe the more you talk to people over the phone, or face to face, you do get better performance, so I think it’s a big thing.”

(MRO)

The use of social networks as discussed earlier, was seen as important and was argued to be important to identify supply chain disruption risk.

“One of the things I’ve done in the past is when starting off a new relationship with a supplier or in fact maintaining current relationships, is to put together a way of working documents, which identifies all communication links between the two companies, between the different tiers between the organisations so that both parties are very clear on the structures and lines of communication so that you do get this networking throughout both organisations and not just at one level.”

(Strategic Sourcing)

“It will be a new process. The social networking that goes on, from my experience here, it used to be on an ongoing relationship at the buyer/sales level. At the early stages of development you’ll get the engineering social network. Once, you’ve implemented a program it’s more at the front end of the business.”

(Strategic Sourcing)

The ad hoc use of financial checks on suppliers, but not routine or regular ones was seen as the current process of risk identification in the OEM. The OEM was also argued to be the last to know about risks in the supply chain in reference to raw material risks. Social contacts were seen as important to identify risk in the supply chain, with face to face meetings and telephone contact argued to be better than other methods of communication such as email.

4.6 Thoughts on Developing Social Networks

The OEM feels ambiguous about developing social networks with suppliers. There is no formal process of mapping social networks or identifying communication flows between individuals in the OEM and the supplier organisation:

“I don’t think there’s a formal process that documents when these guys go on a visit to suppliers. With a customer there’s a formal visit report that is put on, five particular questions are asked, I don’t know if there is one in the buying function, if there isn’t it would be a good idea, you could get some consistency, you can have the single format that asks particular questions. That would improve the communication flows, I think it comes down to the social contacts and people.”

(Finance)

Perceptions of the level of importance of a supplier and supply chain risk have had little attention in the literature. The level of importance of the supplier and the level of social contact was seen as important:

“I think certainly the way our procurement and strategic sourcing is structured. We don’t have contact with senior level people in some of our suppliers, so in terms of strengthening those we could get our sourcing or procurement manager and Operations Director could spend more time cultivating relationships with our top 5 suppliers. The same way I would expect our sales/marketing people will be cultivating relationships with our top 5 customers. Our Operations Director would develop relationships with our top 5 suppliers.”

(Operations)

Developing social networks with suppliers were also hindered by the concern that suppliers will not take ownership for risk in their organisation, and not wanting to manage other peoples business:

“Once you start undermining your suppliers too much, then they won’t take ownership.”

(Purchasing)

“If we go too far we will be managing other peoples’ businesses. We should be managing our own business.”

(MRO)

“You want people to interact with suppliers because of the risk issue, but you don’t want to breach ethical issues.”

(Supply Chain)

The level of importance of the supplier and the level of social contact was seen as important and not been researched in current literature. However, the building of social networks with suppliers is hindered by the views that once you start interacting with suppliers too much, they will not take ownership for their own risk management processes, also ethical issues need to be considered.

4.7 The Depth of Social Network Application

OEM's have transferred risk down the supply chain, and have lost direct control of the information flows at the basic supply and demand level (Bales et al., 2004). Thus this line of enquiry begins with exploring the depth of social networks in the supply chain.

How far down the supply chain should the OEM develop its social network?

- “Depends on sophistication of first tier supplier”*
(Strategic Sourcing)
- “All the way down to raw materials”* (Operations)
- “Difficult to extend it beyond first tier”* (Supply Chain)
- “Depends on how useful it is to the company”*
(Purchasing)
- “Supplier’s suppliers only”* (Purchasing)
- “Once you start undermining your suppliers too much, then they won’t take ownership.”*
(Supply Chain)
- “Depends on who the key suppliers are”* (Finance)

These quotes show that there was mixed views regarding how far down the supply chain the OEM should develop its social network. Some argue that it should be all the way down the supply chain to raw materials, others argue that this isn't feasible beyond the first tier of the supply chain.

“I think it would be quite difficult to extend it beyond the first tier. Maybe the way is to encourage the supplier to do a similar type of exercise.”

(Supply Chain)

"I think it could be quite difficult to extend the social network unless you do through third party things such as trade organisations, attending trade conferences where you tend to pick up from a wider group of people. Other organisations such as the SBAC tend to get to the many tiers of the supply base. It's more a case of building working case relationships where they let you know what's going on in advance."

(Supply Chain)

It was also argued that the social network should extend beyond the first tier and all the way down to raw materials:

"Technically it can go all the way through. But I think what's useful to a company; otherwise if it's irrelevant, it just becomes a friendship. That's probably how far as it needs to go."

(Purchasing)

"We need to look at it all the way down to the raw materials."

(Operations)

"That's a difficult one. I think there's mixed views, I think if you go too far down you start going to suppliers, suppliers, suppliers you may be undermining and once you start undermining your suppliers too much then they won't take ownership."

(MRO)

The OEM did have contacts that extended beyond the first tier and into the second tier of the suppliers:

"We often use our suppliers' suppliers directly. Also, our quality systems make sure any one of our suppliers' suppliers have to be approved by the OEM, so we're pretty much aware of the contacts of our suppliers' suppliers. So I think it's quite important, the more contact you get the more knowledge you gain of the industry itself. I think it's quite a good thing knowing our suppliers' suppliers but it is a must to have approved sub-tier suppliers."

(Purchasing)

The depth of the social network should also depend on the sophistication of the first tier supplier:

"I would say it's dependent on the level of sophistication of your first tier supplier. If your first tier supplier is very sophisticated, he's got KPI's and he's got his social networks with his tiered supplier and you can then limit your networking. But if you've got a relatively unsophisticated first tier supplier who you've got to put a lot of time and resource into, you may want to extend your social networks into this first tier supplier. The further back you go until you are happy that all the risk factors you've identified are mitigated, then you can pull back. So it's dependent on the level of sophistication of your first tier incumbent supplier."

(Strategic Sourcing)

The SME also had a common perception as to which of its suppliers that it found to be most at risk. However, no formal process of mitigating that risk was in place. There was disagreement as to how far down the supply chain the social network of the OEM should extend. However, the OEM did have social networks that extended beyond the first tier of the supply chain. An interesting argument was that the depth of social networks in the supply chain depends on the sophistication of the first tier supplier. If the first tier supplier is sophisticated and has its own social networks with its suppliers, the OEM doesn't need to extend its social network beyond the first tier. Therefore less resource needs to be put into building social networks all the way down the supply chain, since the first tier supplier has already got social networks down the supply chain from which to draw upon.

4.8 Are Social Contacts a Good Way of Identifying Risk?

Now that it was established that some form of social contact and networks extended from the OEM into its suppliers, and possibly beyond, it was questioned as to how important are social contacts to identify risk:

It was seen as a good thing and important to use social contacts to identify and help mitigate supply chain disruption risk:

"I think the contacts and information is a good thing, but I think it needs to be formalised not just a whole series of whispers and grapevine if you like. A procedure or documentation is required between them and a review so you can get something out of it."

(Finance)

"I think yes, really we should be working together. We deal as much with our suppliers as we do with ourselves. On a social level, we would hope we could identify problems together if it affects both of us."

(Purchasing)

"I think it can be good. If you've got a social rapport with people when you meet people, people are going to go a little further for you."

(MRO)

It can be seen that social contacts and social networks with suppliers is seen as a good way of identifying risk. It also wasn't seen as a problem and the interviewees acknowledged that social networks do exist and are used on a daily basis.

"I don't think we've got a problem there. This is raw materials."

(Purchasing)

"We're usually aware of what's going to market wise. I'd like to think we're pretty proactive in this sort of thing, but we've got some good solid contacts we've known for a long time."

(Purchasing)

"I'm not as close to the suppliers as the purchasers are, they deal with them on a daily basis, I deal with the senior people when we have a problem. The buyers have daily contact with people. XYZ had an issue that somebody else had bought them, but our buyers knew, they have good contacts with them."

(Purchasing)

Risk information coming through the suppliers was seen as common place, due to good relationships with suppliers and possibly friendships between individuals.

"It's fine, you can often quite pick up a lot of information from a contact, from a verbal chat, and you will often hear in their circles maybe a company struggling or a certain item is becoming at risk or that sooner or later it may become obsolete."

(Purchasing)

"In the electronics industry that's quite common. The more sources of identifying risk the better in my opinion. If someone tends to share information with you and it's to the benefit of the company, it's fine."

(Purchasing)

"I think it's extremely important."

(Strategic Sourcing)

“A formal process which is the fact that you’ve got a particular issue, or problem, with a particular supplier and that’s how I’ve done it in the past and certainly with the new strategic suppliers we’re setting up the way forward as something the same way of producing a way of working document that is agreed by both because a majority of risk is communication and that can be resolved by communication.”

(Strategic Sourcing)

“It will be a new process. The social networking that goes on, from my experience here, it used to be on an ongoing relationship at the buyer/sales level. At the early stages of development you’ll get the engineering social network. Once, you’ve implemented a program, it’s more at the front end of the business.”

(Strategic Sourcing)

It was seen as important that relationships between suppliers and the OEM were cultivated and used to identify risk. It can be seen from the above quotes that it was the views across functions within the OEM. One argument being that formal processes need to be implemented, so that the social contact doesn’t just appear at the beginning of a relationship with a supplier, but throughout the relationship.

4.9 Problems of Sharing Information

The problem with the sharing of information was also seen as hindrances to the building of social networks with individuals in the supplier organisation.

Disclosure of information with regards to PLC rules was seen as an important reason why suppliers may not provide information that a risk is on the horizon:

“There is a difficulty in this which is legal issues with PLCs. If an employee discloses that a company is in difficulties, share trading issues follow on from this so you’re very wary of not breaching any insider trading issues. People who are in a company that’s in trouble may not also breach guidelines of that company, so there are limitations of the information that you can get that are not breaching the boundaries of legal correctness.”

(Supply Chain)

The OEM's ethics policy was also seen as a factor which may restrict the flow of information between the OEM and supplier organisations:

"We don't encourage too much contact on the social side due to general ethics policy because everything needs to be kept on a reasonable business level. If a buyer spends all his time lunching with a supplier there could be questions asked. So how do you set the balance so there is a trade off between ethics policy and social networks."

(Supply Chain)

"You want to encourage people to interact with suppliers because of the risk issue but you don't want to breach ethical issues of becoming a preferred supplier because of social offers, but a preferred supplier because of the pricing structure. We pride ourselves in the fact that we don't have any social offers in the bidding process which may cloud our judgement. When we are a small customer of a large company that's where social networking becomes difficult. For example one of the people at ABC told us he was retiring before it was announced in his own company."

(Supply Chain)

If communication isn't flowing then that also will be a hindrance:

"Communication is not flowing... I think that's the major thing that we're hearing about."

(MRO)

As suppliers become more globally placed or positioned, location wise, communication will become more difficult, especially face to face contact, as is currently happening with local suppliers:

"As things begin to get more and more global it's going to get more difficult."

(MRO)

This can be further dampened by cultural issues with global suppliers:

"From my point of view, we've got some French suppliers and what I can't totally understand is we were struggling to speak to the people in France it was difficult getting hold of them and lots of voicemail messages. When we actually spoke to them they were very helpful. But when we were trying to correspond by emails, they were taking a long time responding. I've since found out it's probably a French cultural thing where it's almost like since they've put something in writing it has to happen."

(MRO)

The problems of communication tools such as email and fax, where face to face contact is eliminated, is seen as a hindrance to communication flows:

"It's once you've had that direct contact with them, I mean over the phone is a lot better than email, I think we're in a society now where the email is taking over. I believe the more you talk to people over the phone, or face to face, you do get better performance, so I think it's a big thing."

(MRO)

There also can be a problem of too much communication, these pitfalls of being too close to your social contacts are argued by Galaskiewicz (2011) because relational ties are too thick, he goes on to argue that a smart network should have both strong and weak ties:

"I think you can go one step further, I think you can have too much communication that you can manage. If you go too far, and manage other people's businesses. We should be focusing on our own business."

(MRO)

The other problem to communication is suppliers tend not to communicate when they are having issues or problems:

"The problem is they're not very forthcoming when they're in trouble."

(Purchasing)

There are many problems with the sharing of information between suppliers and the OEM, as seen in this section. PLC rules, the OEMs ethics policy, lack of flow of communication, the globalisation of suppliers, cultural issues and methods of communication, all hinder the level of information sharing between the OEM and suppliers. All of these issues need to be addressed if the identification of risk needs to be built into the OEMs risk mitigation processes.

4.10 Solutions to Identify Risk

Solutions to identify risk were varied, ranging from assessing suppliers financial stability, increasing social contact and understanding relationships, having supplier health checks, and using OEM and supplier forums to increase communication:

“That’s where you get your risk, that’s where you have to investigate and assess those in terms of their financial stability.”

(Finance)

“That was through the social networking side; it is actually understanding the core relationships. The problem is you cannot always do that when you’re at risk. I think what we need to think about is a suite of indicators.”

(Supply Chain)

“It’s once you’ve had that direct contact with them, I mean over the phone is a lot better than email, I think we’re in a society now where the email is taking over. I believe the more you talk to people over the phone, or face to face, you do get better performance, so I think it’s a big thing.”

(MRO)

“Maybe we should have a supplier forum which is more than just a price exercise, but actually how well the business is going. What we should be thinking about is having a health check visit with critical suppliers to see how well they are operating.”

(Supply Chain)

“Having your finger on the pulse, that would go to mitigating some risk. Certainly you mentioned networking earlier, we’re all at the professional side of the industry, members of various industry bodies. As a part of that we undertake a lot of networking with our professional institutes. That’s one way we can learn where the industries are going; where there may be a risk with certain suppliers. That’s networking within the industry bodies.”

(Strategic Sourcing)

The finance interviewees view was that the financial stability of the supplier needs to be assessed to identify if there is a risk on the horizon, as opposed to the supply chain view where health checks of suppliers needs to be assessed on a regular basis and having a suite of indicators or triggers that identify when there is a risk in the supply chain. The strategic sourcing view was that networking within industry bodies will give a better overview of what’s happening in the supply chain.

4.11 Pushing and Pulling Information

There is a lack of models in analysing the supply chain risk associated with information flows (Tang and Nurmaya, 2011). Jorge (2009) suggests avenues of future research into how can information management, IT and unpredicted interventions and sources of instability in the supply chain be modelled. The importance of information management and the supply chain is also highlighted (Jorge, 2009).

The interview transcripts were therefore thematically analysed and information flows were assessed as whether they were pushed into the OEM by suppliers or pulled into the OEM by individuals in the OEM. Examples of cases where information was pushed into the organisation are:

“It was ABC that first contacted us, that XYZ was about to go into receivership. And then a couple of days later we got from both the receiver and people from XYZ that they had gone into receivership.”
(Operations)

“It was one of the senior guys at XYZ who tipped ABC off in our laboratory.”
(Purchasing)

“I think it tends to come from word of mouth from the contacts within the business i.e. our buyers dealing with their salesmen.”
(Finance)

“Some companies will let you know, some companies will phone you up. Different people in the organisation, from your main contact to production manager may phone you up, i.e. this product has got a problem, give you more time to deal with these eventualities.”
(Purchasing)

It can be seen that information was pushed into the organisation from the above quotes. This is where the supplier has contact the OEM and passed on information which the OEM hasn't necessarily asked for. It has been done under the initiative of the individual in the supplier.

Information was also pulled into the organisation by individuals in the OEM, some examples of these are:

“Worse case scenario, we send off a hit list as this should be in this week. I’ll phone up where it is, and a lot of the time suppliers will let you go all the way, so there’s no planning time.”

(Purchasing)

“Keeping a close eye on the financial stability of a company; acquisition and mergers and any changes in the industry.”

(Strategic Sourcing)

“Having your finger on the pulse, that would go to mitigating some risk. Certainly you mentioned networking earlier, we’re all at the professional side of the industry, members of various industry bodies. As a part of that we undertake a lot of networking with our professional institutes. That’s one way we can learn where the industries are going; where there may be a risk with certain suppliers. That’s networking within the industry bodies.”

(Strategic Sourcing)

“That’s where you get your risk, that’s where you have to investigate and assess those in terms of their financial stability.”

(Finance)

“The triggers tend to be identifying someone’s financial state, for example using DandB reports.”

(Supply Chain)

The information when pulled into the OEM, is done under the initiative of the individual in the OEM. The individual thus would contact a supplier or other organisation to assess and request the risk information that they deem they require.

It was seen that information and triggers of supply chain risk was both pushed and pulled into the organisation, these flows need to be investigated further, through the propositions of the research (chapter 5) and the testing of these propositions.

4.12 Features of Network

In chapter 2 when reviewing the social networks and constructs, a number of constructs were identified, these being:

1. Size
2. Centrality
3. Reachability
4. Diversity
5. Openness
6. Stability
7. Density
8. Relational ties

These constructs will be used to further analyse the OEMs network based on the analysis and quotes from this chapter:

4.12.1 Size

The number of individuals or organisations in the network of the OEM wasn't clearly evident from the interviews. However, the small size of the OEM was highlighted:

"We've had to get closer to our suppliers, because we're a smaller size."

(Purchasing)

"Due to small size of organisation, social contacts are important".

(Supply Chain)

The size of the network could still be large even though the OEM is small, so one cannot come to any conclusion as to the size of the network.

4.12.2 Centrality

The centrality of the OEM in the network couldn't be easily seen from the analysis of the interviews. The OEM was at the top of the supply chain analysed however importance in terms of degree centrality or betweenness centrality could not be easily analysed.

4.12.3 Reachability

Again the reachability of the OEM and the density of the network couldn't be easily analysed from the interviews.

4.12.4 Diversity

The network of the OEM seems to be well established and diversity of the network in terms of the networks of individuals seems to be not diverse:

"It will be a new process. The social networking that goes on, from my experience here, it used to be on an ongoing relationship at the buyer/sales level. At the early stages of development you'll get the engineering social network. Once, you've implemented a program it's more at the front end of the business."

(Strategic Sourcing)

The network is well established between certain individuals from certain departments, so little diversity appears to exist in terms of profession.

4.12.5 Openness

From analysing the interviews, there seems to be well established relationships within the supply chain however this does not seem to go beyond the supply chain or from the OEM down to further tiers of the supply chain.

"It's based on hard facts...but we've got some good solid contacts, we've known for a long time."

(Purchasing)

"We have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based."

(Supply Chain)

However, it was suggested that in the future networking could increase and increase the openness of the OEM, through networking of industry bodies:

"Certainly you mentioned networking earlier, we're all at the professional side of the industry, members of various industry bodies. As a part of that we undertake a lot of networking with our professional institutes. That's one way we can learn where the industries are going; where there may be a risk with certain suppliers. That's networking within the industry bodies."

(Strategic Sourcing)

4.12.6 Stability

The networks with some suppliers in the supply chain are very stable due to the longevity of relationships:

"It's based on hard facts...but we've got some good solid contacts, we've known for a long time."

(Purchasing)

"I think so, because we've been the smaller one of the wheel and brakes set up, we have been closer to our suppliers because we're a smaller size."

(Purchasing)

"(The OEM) has got a history with lots of the suppliers – 20, 30, 40 years. They still look at (The OEM) as one of their key people but we may not have such a great spend with them."

(Purchasing)

The small size of the OEM also leads to a more stable network due to closer relationships with suppliers.

In other cases, networks are created all the time due to new suppliers becoming apart of the supply chain, and also individuals leaving the OEM or the suppliers:

“We would just drop in and build our own social network depending on the problem. We are looking at the supply chain at the moment. Just because of the role we are doing, we will create our social network as and when we drop into something.”

(Supply Chain)

“Everyone’s got their own network.”

(Supply Chain)

“At ABC my main contact has just left, whom I got on very well. We’d chat and also get a lot done. But he’s left. So I’m starting again with the next one. As it is all changed we’d probably visit them.”

(Purchasing)

The network of the OEM is therefore stable in terms of longevity of relationships but also dynamic because of new suppliers and new contacts within the suppliers and the OEM.

4.12.7 Density

The density of the network of individuals or the OEM couldn’t easily be analysed from the interviews. Individuals in the OEM have networks with individuals in the supply chain, however this does not indicate how dense their networks maybe.

4.12.8 Relational Ties

The relational ties between individuals and the OEM and suppliers were evident from the interviews:

“Some of our suppliers we do have a good spend with such as XYZ fairly good spend with, with ABC, not a massive spend with them but they’re a massive company we do have fairly good contacts.”

(Purchasing)

This suggests that instrumental ties are evident in terms of spend and information

exchange.

Affective ties in terms of friendships between individuals were apparent.

“The example with XYZ retrospective study, was we had no upfront knowledge it was going to happen and probably the only way of finding out about these things is through social networking, which is building a good relationship with suppliers so that they feel that they are obliged to let you know that a risk on the horizon, through a friendship basis.”

(Supply Chain)

“At ABC my main contact has just left, whom I got on very well. We’d chat and also get a lot done. But he’s left. So I’m starting again with the next one. As it is all changed we’d probably visit them.”

(Purchasing)

However, the friendships were not seen as acceptable and contacts should be only on a work basis:

“It’s, culturally, we don’t really do it, nobody goes on socials. It depends on the suppliers, but with the people who do would have been here a lot longer.”

(Purchasing)

“Only on a work basis.”

(Purchasing)

Moral ties within which reciprocity was also evident, with individuals feeling obliged to go further for you, and let the OEM know about risks on the horizon:

“I think it can be good. If you’ve got a social rapport with people when you meet people, people are going to go a little further for you.”

(MRO)

Summing up, the interviews did show that many relational ties exist between the OEM, individuals in the OEM and suppliers and their employees.

4.13 Outsourcing and Risk

The interviewees in the OEM were asked to discuss their views on whether risk is moved down the supply chain as products are outsourced to suppliers.

There were mixed views as to whether risk is passed down the supply chain. The

Finance interviewee argues risk does increase when outsourcing products and it would be easier to manage risk if all production was within the OEM:

“That can be a risk, we’ve had an incidence of that in the past where we’ve put something out, where a company we audited outsourced their work to someone else, they were not as rigorous in their quality checking, vetting, etc. We suddenly found they got out of spec. The more remote you get the more difficult it is. Yes I would say the risk would increase. If everything was under your own roof it would be easier.”

(Finance)

Risk does increase when outsourcing products but risk has to be seen as a shared problem between the OEM and its suppliers.

“I think the risk as outsourcing goes on is that the risk becomes less physical. If you are no longer buying raw materials you lose control of what’s happening in the raw materials market, so you are putting yourself more at risk due to lack of visibility or day to day contact.”

(Supply Chain)

“I think it’s a bit unwise/arrogant that you can pass the risks onto the supplier.”

(Supply Chain)

“The reality is it’s a share problem. I think you do lose more contact to see the risk as the more you outsource.”

(Supply Chain)

There were also mixed views on risk, that when outsourcing you do expose yourself to more risks, but on the other side having production on one site also exposes the OEM to risks.

“I think the more you outsource you expose yourself to more risks. The question is is it a bigger risk. I think if I can control it in-house, I can control the risk. The flip side is if you’re risking everything on one site you’re exposing yourself to disasters.”

(Operations)

“I think you’re not increasing risk as you outsource, but you’re exposing yourself to different risks. And you can’t manage your supply chain on your in-house manufacturing. With supply chain you have to actively manage your risks. I think there’s a weakness in our strategic sourcing methodologies, that doesn’t look at the risk profiles of our suppliers or the risk supplier of the company ends up with when going to certain suppliers, i.e. the obvious check the financials of a company what you don’t necessarily do, is who are the other customers, what leverage do they have. What’s the ownership structure, does the business have continuity plans. So, I think inevitably the

risk profile changes. As buyers do we understand that we need to manage that.”

(Finance)

Others argued that even if you outsource the product still has to come into the OEM so risk isn't necessarily passed down the supply chain, its ownership is still with the OEM.

“Even when we outsource something it still has to come in here. Yes, ok there is another step in the chain, if a supplier has a supply problem, they will supply you information at the time. And because its further down the supply chain, you're giving yourself more lead time, but their capabilities with deciding that issue is there, probably no.”

(Supply Chain)

“In terms of us and customer focus, all that risk goes back though the supply chain and will lie ultimately with us. When we're customer facing, we need to mitigate all the supply factors down the supply chain. Customers won't be interested that two or three levels down the supply chain Fred Blogg's furnace has broken down; the risk is ours. We need to mitigate that.”

(Strategic Sourcing)

Risk was seen as being passed down the supply chain, and other factors come into play when outsourcing, such as logistics risks and delivery risks.

“The risk if you extend your supply chains is you're passing risk down the supply chain. The longer the supply chain the greater your exposure to risk because of the additional factors that come into play, like logistics or delivery issues or risks on quality for example; they will be exacerbated along a supply chain.”

(Strategic Sourcing)

In summary, risk was seen as being passed down the supply chain when outsourcing products. However, it has also been argued that risk is shared problem between the OEM and suppliers, and the final product still has to come to the OEM from the supply chain, so seeing risk as being outsourced isn't in the best interest of the OEM. A common approach to risk identification and mitigation between the OEM and suppliers needs to be developed.

4.14 A Comparison of Supply Chain Risk Perceptions in the OEM and Tier One Suppliers

This chapter has summarised the views of individuals across functions within the OEM with regards to the importance of social contacts, level of social contacts, and depth of supplier social contacts within the supply chain. The types of risk were also explored. These risk perceptions were seen as a fundamental reason to have social networks and other risk identification measures to help with the risk mitigation process. However, these risk perceptions need to be aligned with the risk perceptions of the suppliers, so that a common risk mitigation process can be identified. Therefore an interesting thread of research that follows on from previous sections, is do the risk perceptions of the first tier suppliers align with the risk perceptions of the OEM?

Whilst supply chain risk has become a topic of great interest to supply chain researchers, few studies have used the supply chain as a 'unit-of-analysis' to track how perceptions of risk of the same component streams vary at different tiers along that chain. The understanding of differences in risk perception is crucial in devising effective approaches to mitigate against risk. There have been studies in exploring the different perceptions between managers in different countries and cultures (Zsidisin et al., 2008). Ellis, et al. (2009) explore buyer perceptions of supply chain disruption risk and find that these perceptions vary as to the magnitude of disruption risk. However little focus has been put on the perceptions of individuals in an OEM and it's suppliers as to supply chain disruption risk.

This section reports on an investigation that proposes that perceptions of risk will change along the supply chain. The analysis begins by giving a brief overview on the literature on supply chain risk and the lack of coverage of variations of risk

perception across the supply chain. It presents the results of a case study investigation into the proposition in the aerospace sector into the differences in risk perceptions between and OEM and four of its tier one suppliers. It shows how the proposition is partially supported and how disparities in perceptions could be partly attributed to complex supply chain interactions and partly attributed to informational inequalities at different tiers. It also discusses findings on risks in supply chains that lie outside the original goals of the investigation but highlight the difficulties of dealing with 'unknown unknowns' in a supply chain risk context.

Given the critical need for holistic considerations of supply chains in other areas of their design and management, it is unsurprising that information sharing and communication and coordination among all elements of the supply chain is essential to reduce supply chain risk susceptibility.

Given that the nature of actors changes at different levels of the hierarchy in the supply chain internal structure, and the likelihood of suppliers being a SME (Peter, 2004) it is likely that the perceptions of risk of those actors will vary as well. It could therefore be argued that supply chain risk frameworks cannot be considered as unitary constructs that will work in the same way at any point in the supply chain. If perceptions in risk do change across the supply chain, then it is important that these are understood so that effective flows of information can be maintained along the supply chain to mitigate against these risks. However, very little work has been undertaken to establish if such a variation of risk perception can be discerned. The research question that the investigation seeks to explore is therefore as follows:

How do supply chain practitioners perceptions of supply chain risk vary at different points along the supply chain?

4.14.1 The Investigation Methodology

The lack of literature in this area meant that this investigation was highly exploratory in nature. In these circumstances, case study enquiry is a particularly pertinent research methodology. The case study enquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points. (Yin, 2002).

4.14.2 The Case Study Design

The context for the case study was the aerospace sector. The aerospace sector was selected as a useful environment to investigate supply chain risk as many of the perceived supply risk factors are very prevalent in the aerospace industry. These include scarcity of raw materials, low volumes, high complexity of components and a high number of 'monopoly' suppliers. The aerospace OEM that is the subject of this investigation is a wholly-owned subsidiary of a parent organisation that has an UK head-quarter but has substantial global subsidiaries including a large number of facilities and subsidiaries in the US. The OEM's parent company was ranked in the global 'top twenty' by turnover of aerospace organisations. The key components of the case study design are captured in Table 4.1.

Table 4.2: The Case-Study Design (c.f. Yin, 2002)

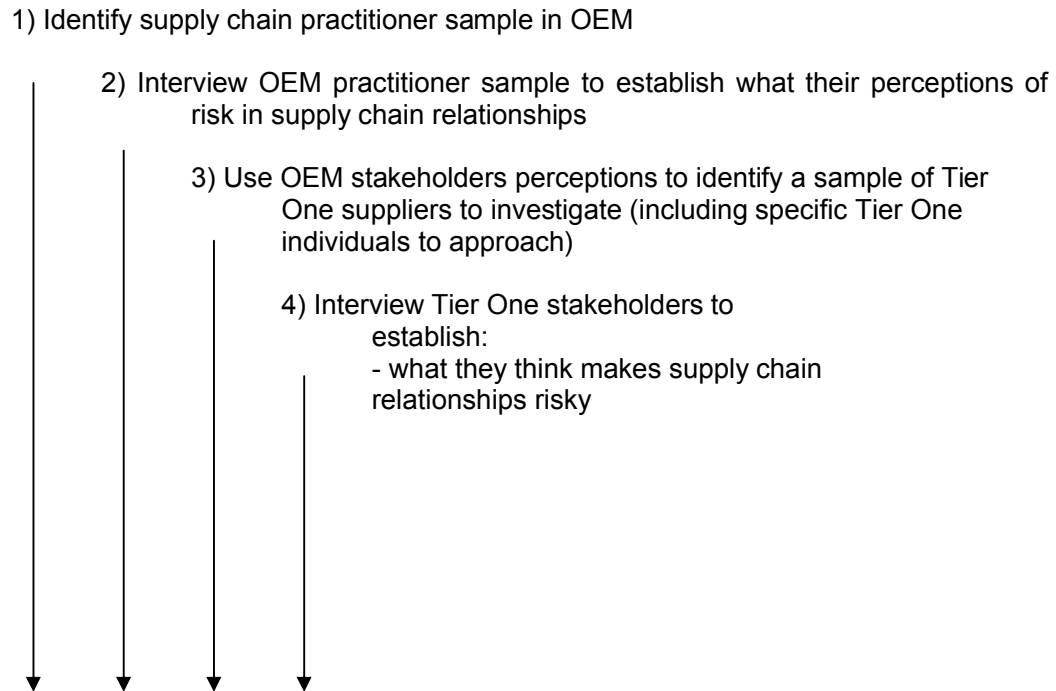


Source: Yin, (2003).

The investigation was confined to the dyadic relationship between the OEM and tier one suppliers. The rationale for this was that, if differences of risk perception were spotted between 'close' members of a supply chain then risk perception are likely to vary substantively from the highest to the lowest echelons of the supply chain network.

The protocol followed by the case study is shown in Figure 4.1. Data was collected from semistructured interviews that were conducted using the seven stage process suggested by Kvale (Kvale, 1996). Thirteen supply chain related practitioners were interviewed in the OEM in which two practitioners were indicated in each of the Tier One suppliers.

Figure 4.1: The Case Study Protocol



4.14.3 Perceptions of Supply Chain Risk in the OEM

Managing Obsolescence

During the exploratory case study at the OEM, obsolescence was seen as an important source of risk to the organisation. In particular in electronics:

"It is because it's an industry where the obsolescence cycle is 2-3 years. We are in an industry where the products are lasting from 25 to 40 years, so obsolescence and managing obsolescence and total failure of a component supplier is the key risk in electronic suppliers. I think the other key risk is forgings and castings where generally speaking the single sourced castings and forgings. They are not a monopoly supplier because of the switching logistics/costs is the problem. And you generally want to buy one set which you tend to own, but getting that off somebody and getting it recognised is a problem."

(Operations)

"We cannot compete with the commercial electronics market. No one wants to deal with the aerospace market. And the speeds of which electronics products are moving on.... we can't keep up with change, within the electronics market."

(Supply Chain)

“As far as I know the computer equivalent (to existing electronic systems) is a 286 computer, its garbage. Yes, electronics is a massive problem. I don’t think we’re any different in terms of if you break it down, as any company goes, our overheads are affected – rising oil prices we’re all effected by that.”
(Supply Chain)

The OEM perceived its supply chain risk in two distinctly different ways. Firstly it identified ‘risk propensity factors.’ These factors captured the underlying propensity for risk that characterized a relationship. It differentiated these from ‘risk trigger factors’. These factors indicated that supply chain disruption was becoming more likely i.e. supply chain risk was increasing. The prime factor that was identified as a propensity for risk was the single sourcing of a component with one supplier. A secondary factor was the situation where the OEM’s business comprised only a small part of the tier one suppliers business.

‘Trigger’ factors that indicated that risky relationships were becoming likely to cause disruption were identified earlier as:

- Suppliers asking for changes to payment terms
- Late deliveries
- Unexpected price increases
- Poor quality of parts
- Increased lead times
- Staff turnover

Using the risk factors that they had identified in the interview process, the practitioners were then brought together and asked to identify a sample of tier one suppliers who exemplified those characteristics for further investigation. (See table 4.3)

Table 4.3: Tier One Supplier Sample Characteristics

Selected Tier One Suppliers	Single Source Supplier	Low proportion of OEM business	Presence of recent 'trigger' factors
Company A	X		Quality and delivery problems
Company B	X		Delays due to raw material supplies
Company C		X	Purchased were becoming obsolescent
Company D	X	X	Lead-times for delivery were increasing

4.14.4 Perceptions of Supply Chain Risk in Tier One Suppliers

The data collection for the investigation took a problematic turn when Company A and Company B failed to participate in the case study. Originally Company A agreed to participate but a senior supply chain manager refused when the researcher arrived on-site to conduct the interviews.

Company B did not explicitly refuse to participate but avoided contact in response to email and telephone requests. In order to investigate the companies' reluctance to participate, researchers looked for secondary data that may provide insights into why this reluctance may have been present. Through these investigations, the researcher identified the following information of which the OEM was unaware:

- Company A was owned by a competitor of the OEM's parent company's other subsidiaries following a recent acquisition and had recently won a significant order for non-aerospace business

- Company B was being de-selected by other parts of OEM's parent company as a preferred supplier

Company C and Company D identified a similar list of risk trigger factors to that identified by the OEM. However, Company C and Company D identified different risk propensity factors.

Company C viewed their relationship with the OEM substantially differently and did not view the risk in the relationship as due to a material supply chain issue. Company C viewed the risk in the relationship due to the OEM's inability to communicate its future usage of the components it provides to the OEM. Company C argued that if it was aware of the future usage patterns it could resolve issues of electronics obsolescence immediately. Company D identified that the relationship with the OEM was more risky than the OEM was aware. Although Company D was a single source for the OEM, the OEM thought that with further accreditation it could obtain a similar component from Company D's competitor, Company E. However Company D's Tier 2 supplier for a critical sub-component was a company owned by Company E that also supplied Company E. The OEM was unaware that whether it sourced with Company D or Company E it would still result in using the same sub-component supplier.

4.14.5 Conclusions of Perceptions Study

The aim of this exploratory investigation was to understand if perceptions of supply chain risk varied at different points in the supply chain. With all of the provisos pertaining to the validity and reliability of a case study approach, the results of this investigation partially support the proposition that different actors on a supply chain hierarchy will consider risk differently. Both Company C and Company D identified

different risk propensity factors for their relationship than the OEM identified. Both tier one suppliers viewed that the relationship that they had with the OEM had a different propensity to risk than the manner in which the OEM viewed the relationship.

However, the proposition is not supported in other ways. The OEM, Company C and Company D all identified similar 'risk trigger' factors. This implies that although they may view the relationship as having different risk propensities, they would use the same 'risk trigger' factors to understand if the relationship was becoming more likely to be disruptive i.e. more 'risky.' The failure for Company A and B to participate highlighted an important issue in assessing supply chain risk that did not form an objective for the original scope of the investigation. The relationship that the OEM had with Company A and Company B had changed (and potentially become more 'risky') without its knowledge. This highlights the paradox of risk assessment where the risks that may be most potentially dangerous can lie in the region of 'unknown unknowns.'

This investigation has demonstrated that the area of risk perception along the supply chain is one that is worthy of further investigation both qualitatively and eventually quantitatively when the constructs have been clearly defined and operationalised. Indeed, the holistic understanding of supply chain that it is argued by so many as fundamental to optimal supply chain management may prove impossible without a greater understanding of how perceptions of risk vary in the supply chain.

4.15 Chapter Summary

A case study consisting of semi structured interviews with practitioners from the OEM have been conducted and reviewed in this chapter. Two further case studies

were conducted in the OEM's suppliers to further explore the differences in perceptions of the suppliers and the OEM in regards to disruption risk in the supply chain. It was found that these perceptions differed when compared and will be discussed further in chapter 6.

The exploratory case study found that social networks are being used daily to identify disruption risk; however no formal processes are in place that identifies risk through social networks. All interviewees agreed social networks are important. The triggers to risk also were seen to be coming into different departments in the OEM.

The following chapter will look at the propositions that were developed from the exploratory aims and the reasoning behind them. The propositions will then be explored through the focus group findings also in the following chapter.

Chapter Five - Propositions/ Findings about Propositions

5.0 Introduction

The exploratory case study in the OEM helped develop the exploratory themes explored in chapter three into propositions for this thesis. This chapter will explore the propositions in more detail, and also why they have been developed from the research themes. The focus group findings will then be explored. These will elaborate on the findings about the propositions. Each section will begin with a summary of the findings followed by relevant quotations. The quotations in bold are where there is a comment included by the moderator.

5.1 Propositions

The propositions that were developed from the research themes are:

- By improving information flows, through the use of social networks, we can identify supply chain disruption risk.
- The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

5.2 Why Did the Exploratory Themes Lead to the Propositions?

Information flows through social networks are important to identify supply chain risk. The exploratory case study found that social networks are currently being used to gather information to identify supply chain disruption risk. This process is tacit and

not formalised. Thus by improving these information flows, the organisation can identify supply chain disruption risk more effectively.

Supply chain risk information management was identified as an area of improvement in the exploratory case study. The triggers to identify risk were received into different departments of the organisation. The management of this information needs to be further explored. An emerging theme from the exploratory case study when analysing the triggers to identify risk, was that information can be pushed or pulled into the organisation. The push and pull concept can be used to explore the management of supply chain disruption risk information in the organisation.

Both propositions have provenance through the findings of the exploratory interviews and are not explored in current research or published literature.

5.3 Findings About Propositions

Two focus groups were conducted at the OEM organisation. These will be referred to as OEM1 and OEM2 in the following sections.

Two academic focus groups were conducted at Aston University, Birmingham. These will be referred to as Academic1 and Academic2 in the following sections.

5.4 Purpose and Aims of Focus Groups

- Discuss and analyse ways of improving risk management in the supply chain, through discussion of social networks
- Discuss current position of organisation in terms of push and pull concepts of risk information management
- Discuss ideal position of organisation, in terms of push and pull concepts

An example of the questions used by the moderator can be seen in appendix C.

5.5 Key Findings from Focus Groups

5.5.1 Social Networks Used Daily to Identify Risk, But Not Formalised

Social networks were seen as important and were used daily to identify risk. However it was recognised that they are not formalised and they are very tacit in nature:

“social networking and kind of thing is what we all do on a daily basis ... and we make sure we get the right contacts for the right suppliers that we need to have, we have to do that as part of our job.”

(OEM1-Purchasing)

“I’ve still got a good relationship with the people that I deal with, but they are not quite as open.”

(OEM2-Purchasing)

This indicates that there are good ongoing relationships that the Purchasing department have with suppliers, but still these relationships can be improved.

“... if you’ve got a good working relationship with your suppliers, you can sort of get an offer the record kind of feel if there is any problems arising.”

(OEM2-Purchasing)

Good relationships also give early signs that there are problems on the horizon.

These relationships can be seen as an unofficial grapevine:

“several years ago when I was with a different company, I used to get all sorts of comments come through, of course the unofficial grapevine.”

(OEM2-Purchasing)

“If they come and see you all the time, then you’re not going to learn much about them....If you go there and there’s half as many people running around as last time, you’ll think what’s going on.”

(OEM2-Purchasing)

“Sharing information is always a good thing.”

(OEM2-Purchasing)

“On the purchasing side a good contact is worth their weight in gold, for whatever reason, it really is.”

(OEM2-Purchasing)

“with my suppliers, they tend to... I give them information; they give me information, that’s how it works.”

(OEM2-Purchasing)

This again supported the findings from the exploratory case study in the OEM that tacit information was flowing between suppliers and the OEM. This flow of information was due to the loyalty of the supplier and also the need to retain business with the OEM:

“when you get sort of distribution guys they would often warn you about their suppliers having problems, like we had one case where we can’t get some material, or weren’t going to be able to get some material. He told us before that he went to the wall, didn’t he, so it’s quite nice having that ...”

Why do you think he told you that?

“Because obviously it’s going to be a problem for him as well, but he was hoping to retain our business if he source his material from somewhere else but we we’re going to obviously have to sort of change drawings, change our specs ... so the sooner he told us the more loyalty he would earn.”

(OEM1-Purchasing)

Loyalty was a factor in the supplier sharing information in this case. The attendee of the focus group suggests that the motivation of the supplier for sharing the information was to retain business with the OEM.

The automation of tasks also was a problem in terms of the continuing daily contact with suppliers:

“One of the ways of doing that is to become more automated, by doing that there’s a risk you could lose your social contacts because your losing that day to day relationship building but it’s just how you’d manage, that’s what we’re trying to think about at the moment, how you manage that social network if you’re losing the day to day.”

(OEM1-Purchasing)

It can be seen that suppliers are forthcoming to discuss risks in the supply chain, this was something that the exploratory case study found a problem, i.e. the willingness of suppliers to share information when in trouble.

“Now we have got a better relationship with the suppliers at XYZ didn’t they just tell me that, they warn you about things and those things are easy for us.”

(OEM1-Purchasing)

You’re saying there is lots of these risks going on here which can be alleviated through just better communication. Through perhaps something as old fashioned and simple as more meetings or just because you get to know people?

“In a strange way, yeah, because, you know, if there’s a problem there of these guy’s getting in, it’s going cause me a problem and therefore I’m going tell them quite earlier, you know, as soon as they know they literally come in and tell me.”

(OEM1-Purchasing)

However others argue that suppliers wouldn’t be forthcoming when a risk is on the horizon:

“I think if you are dealing with people who are quite at risk to their survival and they are playing the corporate game, you as a supplier, you are the last to know.”

(OEM2-Purchasing)

“It’s quite like X said very rarely would you actually have that supplier pick up a phone and say oh by the way we’ve hit financial difficulties.”

(OEM1-Purchasing)

This suggests that no matter how good relationships are between the OEM and suppliers, financial difficulties will be difficult for the supplier to share, and they would rarely share this information.

The sharing of risk information was also based on key contacts in the OEM and the knowledge of these key contacts with suppliers.

“And when we used to talk about risk and finding out about different things, one of the things we used to say is find out who in your organisation has got the most interface with your suppliers...”

(OEM2-Purchasing)

The OEM focus group attendees also valued the relationships with suppliers and how important it is to gather risk information:

“market intelligence can be vital because you can pick up from that, that your supplier has got a problem, and as I say, that sort of information, the interface between us the buyer, and the suppliers, for getting supply chain risk information is pretty vital. In a lot of companies it was often undervalued.”

(OEM2-Purchasing)

As found in the exploratory case study in the OEM, the locality of the suppliers also increased the relationships and social networks:

“I think with some of my suppliers, they are quite local...So I see them quite regularly when they come in and so we chat to them... and I’ve noticed lately they’re really depressed, and I say are you okay, is everything alright, how’s it going, and you pick up the vibes straight away.”

(OEM2-Purchasing)

As discussed in the exploratory case with suppliers with regards to obsolescence and the risk of electronics, it was suggested that this was still a risk, and relationships are key to identify these risks:

“You are always at risk from the high value low volume requirements, and that’s what’s going to... it’s a risk that you are always going to have to live with, and that’s why market intelligence when you are dealing with anything in that nature is going to be critical.”

(OEM2-Purchasing)

The proactive nature of building these relationships with suppliers was seen as important:

“Relationships are going to be critical.”

(OEM2-Purchasing)

“I’d say build better relationships with the suppliers you’ve got, the suppliers you can use, make sure they understand your business and you understand their business.”

So in a situation where it’s risky, relationship management becomes...

“Relationship management is critical as far as risk management to an organisation like ours.”

(OEM2-Purchasing)

The OEM also saw itself as being information wise, but still can see ways in which this could improve:

“I think we’re lucky in some respects for what we’ve got information wise but I won’t say it’s 100% or anything like it. We still get same situation happening where you get a phone call and it happens and you’ve really got to fire-fight.”

(OEM1-Purchasing)

5.5.2 A Combination of Social Network Risk Identification and Risk Identification Through Formal Methods and Tools Needed

The OEM uses a tool to identify risk called a DNBi tool. It is a tool developed by Dun and Bradstreet, and monitors the risk of suppliers in terms of financial risks. The DNBi tool was seen as a good tool, but the use of social networks to support it was seen as important:

“One of the things I think that D and B information it lacks is that, you know, you’d see trends over time, you’ll see an official file but it doesn’t have – hey guess what I heard - element to that’s not what you find within there, so I think, you know, to your point earlier that both are important do they both serve different purposes, they both provide different types of operation. So you really do to have the ongoing monitoring of day to day.”

(OEM1-Purchasing)

“I was going to say for instance that we get a monthly report on trends from Dun and Bradstreet and I noticed this month that four of our suppliers were at risk. Not hugely at risk but at risk stage, and I happened to have one of the guys come to see me that same day the e-mail came out, and I mentioned it to him, it’s the automotive arm of their sector, bringing the rest of the company down, etc.”

(OEM1-Purchasing)

The DNBI doesn't provide the information that can be obtained from the social network between the OEM and suppliers. Both of these forms of information have different merits.

The OEM saw ways in which they could formalise the informal nature of social network information flows:

"You could formalise it by having a monthly meeting with a supplier and giving out an agenda, something like that so if there's any issue for me but a lot of it is only, as you say, phone call, email whatever. A lot of it's pretty low key."

(OEM1-MRO)

Having some form of formal risk assessment of suppliers was also seen as important.

"And this is why we have our risk management register to say who are the important suppliers that really need to be... We need to be really close with"

(OEM1-Purchasing)

"These are the top 20 suppliers we might expect us to be really close with, regarding relationship."

(OEM1-Purchasing)

There is also formal and informal contact happening between the supplier and the OEM:

"We speak to them probably every day? About various issues going backwards and forwards so while being informal it's probably quite formal as well. They know, when this issue comes out."

(OEM1-Purchasing)

"With all messages be it formal or informal it's always going to rely quite a lot on the relationship you have with either the people you work with or the people that supply you."

(OEM1-Purchasing)

"But also you can build on the information you get from the suppliers, I think it's a bit of both. You can use social networking and the information you get, the facts. Sometimes you get all kinds of stories that are successful and sometimes stories that aren't successful as well, you get whispers about this, that and the other."

(OEM2-Purchasing)

“But it does work out both ways as well, if you talk about hard facts, if I approach my supplier he didn’t even know that himself, I knew that”

(OEM2-Purchasing)

The types of information, whether formal or informal, depend on the relationships built between the suppliers and the OEM. Again, whispers from the grapevine are seen as an informal way that information is shared between contacts. Informal information can also be shared both ways between the OEM and the supplier, where we have information passing to the supplier as well as information coming from the supplier to the OEM.

The DNBi tool was seen as a good way of obtaining facts about risk:

So what you value Dun and Bradstreet for is it’s apparent black and white nature, you know it’s information that’s come from a system, that’s there.

“It’s facts.”

Right.

“Whereas social networking is based on fact but it could be someone’s interpretation of that fact...”

The reason you like Dun and Bradstreet then is because you think there’s some verification gone on there.

“That’s one instance, yes, but as you’ve said before, we do sit and chat about suppliers.”

(OEM2-Purchasing)

The DNBi tool provides hard facts that can result in discussion between the OEM and suppliers, thus social contacts between the suppliers and the OEM, are still important, even though the DNBi tool is used to gather risk information of the suppliers, the social networks help to facilitate discussion around these risks.

5.5.3 Predicted and Routine Risks are More Important Than Unknown Ones

Predicted and routine risks were seen as more important than unknown risks, and the fact that the OEM knows there may be risks on the horizon, which may not cause too much disruption, it was seen as more important than the unknown risk that may cause worse disruption.

So the issue with supply chain risk and managing information for risk, this is quite interesting is getting unknown unknowns, are not important ...

"It's not important ..."

... the ones that screw you up are things you knew about anyway.

"You knew about things that you knew would cause you problem but still it went wrong. If one of our major electronic suppliers were tomorrow to cease business I know that would cause some major problems, but I'd settle for the fact of knowing that would cause problem."

(OEM1-Purchasing)

"so we know that that's high risk, we know that if something went wrong it would cost us a look of money and it would take a long time to actually rectify..."

(OEM1-Purchasing)

This was an interesting discussion around known and unknown risks, with known risks being seen as more important, than unknown risks. This leads on to the question as to how many risks could you actually predict that were actually going to happen from risks that were known:

What percentage of the things that go badly wrong are things which you could have predicted and you knew about?

"You've got to put a time limit on this, over time you, high percentages because again the one's I knew about, I had prior warning, so I think a pretty high percentage."

(OEM1-Purchasing)

"The thing is there's the level of effect. So you're talking about a supplier say going under, that's going to be a big effect. You have a shipment that goes missing; it's going to be a slightly less effect. It's something that you can't predict that. If you see what I mean. Like you know, if they stop supplying bearings tomorrow we'd be in real trouble, like you know ..."

(OEM1-Purchasing)

“Of the top 20 suppliers on MABS’ list that are high risk and those top 20 suppliers only, have a network that make’s sure that we’ve all got information on them, so they’re the top 20 risks and what we need to know is what’s going to happen to these at any time.”

(OEM1-Purchasing)

There were a high percentage of risks that the OEM could predict from risks that they knew about. Also the OEM used the top 20 suppliers at risk as a basis to create relationships or networks with thus confirming that social networks are still important to capture known risks.

5.5.4 Need to React to Risk, Based on Individuals

It was seen as important to have the right people working in the OEM, who could react to risk, people who are flexible and knowledgeable about risk:

“Risk management is about doing something about risk; one way is having good flexible people working for you who can react to risk.”

(OEM1-Purchasing)

The type of people working for the OEM and dealing with risk hasn’t been explored in depth and is an interesting line of research that could be developed further in the future.

5.5.5 Need to React to Risk, Based on Methods and Not Individuals

It was also argued that the people were as important as the method of information management, so having a push system was better, and the people within the OEM were also important as to manage the information:

“The method will be as important as the people. If you have the right process in place, right methods to approach the full information to work together and the push system to implement, I think the method will be as important as the people who are managing the information.”

(Academic1)

In the previous section the OEM discussed how important the people in the organisation are as to dealing with risk in the supply chain. However, the academic focus groups discussed the methods and suggest that having the right methods and risk processes in place are just as important as having the right people in place.

5.5.6 Risk Identification Based on Importance of Supplier

Another interesting finding from the academic focus groups was that the strategy for information management should be based on the importance of the supplier:

“Analyse which is the best supplier and the strategy is needed, strategy for that and also, who is your information source, with information and sometimes it’s difficult...”

(Academic1)

“With your suppliers, is that we are saying, different strategies for each..”

“Do you choose your most valuable suppliers and if you know who will support you or who will bring you more deliverables to your future maybe production or some business operations, then you would still have a longer relationship rather than with some invaluable suppliers, you could even you just ignore them.”

So you’re saying your vital suppliers, you’ll create more relationships within the supply chain?

“It will reduce your cost and also...”

“...with the most important one you could have push systems, less important ones you could have pull systems.”

(Academic1)

The importance of the supplier thus has a relationship to the type of information management process to use to gather information. With push systems being used to gather information on important suppliers and pull systems used on less important suppliers.

It was also seen as a way of filtering information based on trade issues or cultural issues, so you would gate keep the type of information that you would share with certain suppliers:

“And you can decide how much information you can share with them because there will be also some trade issues or cultural issues. So it will be to decide which kind of supplier you have and share information.”

(Academic1)

Again relationship management was seen as important as information management

“I would have thought another way that some companies tackle this problem is, like Toyota and it’s suppliers, having much closer partnerships with their suppliers, having open book accounting, in other words they know what the costs of the item is and what the profit margin is. They have supply and development teams going into their suppliers, so they do have that more day-to-day contact.”

(Academic2)

The role of social networks and relationships between the OEM and suppliers was seen as equally as important as the type of information management between suppliers and the OEM.

5.5.7 Care in Closeness of Social Contacts

The exploratory case study in the OEM found that there was a reluctance to create social networks with supplier organisations because of the ethical considerations; this was also highlighted in the focus groups:

“I think we have to be careful we don’t get too close. There’s got to be a certain gap between it. Too close and it can get a bit claustrophobic and then the supplier thinks – hang-on I know I’ll get all the business because of this relationship, so you have to be very careful.”

(OEM1-Purchasing)

Having close relationships with suppliers can lead to suppliers having the inclination that they will have preferential treatment when it comes time to tender for contracts

with the OEM. Thus there needs to be care in the closeness of relationships between suppliers and the OEM.

5.5.8 Contacts Leave and You Lose Social Network

It was argued that social networks are related to key individuals, and when supplier contacts left, the social network is broken and another network needs to be built:

“The other way round I used to work for a company who supplied Rolls Royce and they used to have a process in place where every 12 months they changed all the key contacts not to get familiar with them, with the supplier.”
(OEM1-Purchasing)

“They went the other way because then you’d have 60 contacts from the OEM going into that client asking for an update, asking the same questions ...”

“Rolls Royce knocked that on the head about two years ago and said no we’re going to have a single point of contact managing order books...It was very tough in the early days but once you got that process in place it made life a lot easier and then it went back to you know stable contact that’s back to normal again.”

(OEM1-Purchasing)

It was seen as important that there were relationships between key individuals in the OEM and suppliers, thus stopping the same questions being asked and the duplication of information gathered from suppliers.

The contacts in the supplier organisation will need to be rebuilt when an individual leaves:

“Mainly one person or two people in that company, because if that person leaves, you cannot get that continuity in that relationship, so you’ve got to start building it all up again.”

(OEM2-Purchasing)

“As I said before, it’s very hard, because if you lose that person, like if I lost a contact I was talking to last week, it would be starting over again, you might not be on the same wavelength whereas with them we are on the same

wavelength because the person will come and see you, none of us have to change personality, to talk open and honestly.”

(OEM2-Purchasing)

Social networks can be seen as important to gather information, and they are linked to individuals in the OEM and individuals in the supplier.

5.5.9 Triggers to Identify Risk

The triggers to identify risk were again discussed in the focus groups:

“The quickest thing would be with accounts we check of accounts in some ways really as to who is the supplier asking for more frequent payments or security ... from my understanding that’s one of our key internal network for support...”

(OEM1-Purchasing)

“You’re dealing with a supplier and then suddenly they come along, wanting to change the payment terms to immediate priority is an issue ... there’s an issue somewhere.”

(OEM1-Purchasing)

“And you would often react by then asking for a D and B report to see...”

(OEM1-Purchasing)

“The guys that speak to them on a regular basis that get to know whether the supplier is having more problems than normal, and if they suddenly start chasing you for money a week before it’s due and all this sort of thing, then you know they’ve got a cash flow problem. Everyone’s got a cash flow problem at the moment, but in the norm, you know, when things are still going on and they start chasing you for money you know they’ve got cash flow problems, and if you find that they are suddenly starting to lay off a lot of other people, not everyone is in agreement that they are laying that particular section off. You can get that information and start to make notes of it and work on that sort of information. Again, if the worst situation comes and they do start ringing, or whatever, you should be ahead of the game and start looking at alternative suppliers.”

(OEM2-Purchasing)

“If they come and see you all the time, then you’re not going to learn much about them...If you go there and there’s half as many people running around as last time, you’ll think what’s going on.”

(OEM2-Purchasing)

These quotes suggest that suppliers asking for changes in financial terms are a trigger that indicates that there is a financial risk with the supplier. Again this

information is gathered through the social networks of the OEM and suppliers and shows how important they are to gather risk information.

5.5.10 Trust Barriers to Social Sharing

Trust came up as an issue which had not within the exploratory case study in the OEM. It was an issue regarding the relationships between suppliers and the OEM:

“There’s another dynamic with social networks in business that might come into play with regard to the willingness to share that information because it’s relationship based. We may have information about a supplier that we may not want to share publically in a greedy type since because that’s, it’s competitive information. It’s information we may understand by a supplier that allows us to react and we may not want our competitors to know that... Saying is that if there must be a formalised informal tool we’d want it internal not external.”

(OEM1-Purchasing)

“We don’t want suppliers to know certain things obviously.”

(OEM1-Purchasing)

“You wouldn’t necessarily want some of these suppliers knowing information about their competitors ...”

(OEM1-Purchasing)

There was also the issue of misinformation and could you trust the information that a social contact may be giving you:

“I mean what you’re getting from somewhere else, it might be rubbish, it might something that somebody made up.”

(Academic1)

“In terms of credibility, it might not be the right information, or people...do you think people might not give you...they can give you false information, like we said before, but we’re human beings, yeah, people will purposely give you false information sometimes.”

(Academic1)

“they (contacts) provide some type information even though it’s not trustworthy... they can create some bad views or bad information for you in relation to the social network.”

(Academic1)

The information gathered from the supply chain by the OEM is important to gather as to ascertain whether there is risk in the supply chain, however the question posed here is, is the information reliable and trustworthy, and would you trust suppliers to provide you with accurate information regarding risks in the supply chain.

5.5.11 Pull Better Than Push, to Avoid Information Overload

All of the focus groups found that pull is better than pushing because you can be selective as to which information that you require and that you can take onus on the information needed.

“Take on board what you want...”

(OEM1-Purchasing)

“But with far too much information, you need to sort it out to one company.”

(OEM1-Purchasing)

“With me personally few emails is enough for me...”

(OEM1-Purchasing)

“We’re at the pull end at the moment, but we should be at the other end...”

(OEM1-Purchasing)

“I just thought if we could pull more information it would help us out beforehand.”

(OEM2-Purchasing)

Pulling information was seen as important, but it was also recognised that when information is pushed, it could be important risk information:

“Looking at both ways, I would not pick up the information I need, but should that information come to you it could be key information...”

(OEM1-Purchasing)

“Don't forget the immediate problem always with any piece of knowledge is how do you work its significance? It may be that you would collect vast quantities of irrelevant items.”

(Academic2)

The type of information management can thus be seen as important and related to the value of information coming into the OEM.

However, pushing information was seen as information overload and made it difficult to select which information was important.

“I think if you’re getting the push information the first thing is you’re getting too much information and it’s your job to sort out which one you want and which one you don’t want.”

(Academic1)

“Being slightly critical, is there a danger though, do you put everything onto it, then it will lose its value?”

(OEM2-Purchasing)

“I want to have a look at such and such today, but I don’t want to have a look at it next week, whereas if you’ve got more of a push situation, you are going to be inundated with e-mails and enquiries.”

(OEM2-Purchasing)

The importance of the type of information sent from a push information management system needs to be balanced by the quantity of information being sent by the system. With too much information gathered making it hard to find and filter the important bits of risk information.

5.5.12 Individuals Will Not Push

Individuals may not push risk information within the OEM due to them being busy and maybe not because the OEM hasn’t a culture of pushing information:

“My concern when we spoke about it some while ago was that it very, very reliant on individuals still taking the onus to dump information into the a system and as we all know we’re very busy people and the concern being is that unless you became very, very familiar as an organisation with this push type system you may have one person not really wanting this to work but if the engineers or the other people in the organisation did not input information then it wouldn’t be a worth while tool ...”

(OEM1--Purchasing)

This again relates to the earlier discussion as to how important are the right people in the OEM as to dealing with risk information, but also as to dealing with the types of risk information management system. With certain types of people dealing better with push systems than others.

Individuals in some suppliers may not be willing to communicate, let alone push information:

“We’ve almost given up speaking to people, mainly because we just can’t get hold of people. We can’t get hold a person to speak to in the corporate, we can’t get hold of people to speak to at ABC and XYZ well he’s very, very difficult, they won’t commit to anything on the phone.”

(OEM1-Purchasing)

This again relates to individuals, but this time in suppliers, so social networks need to be built between certain individuals who would be willing to communicate and push information to the OEM.

The DNBi tool was seen as a better tool than a social network based tool, because it’s not based on pushing from individuals:

“it’s reliant still on individuals rather than the tool as opposed to D and B although it is still relying on information going into the D and B tool it’s more of a safeguard than pushing ...”

(OEM1-Purchasing)

The pushing of information to the OEM from suppliers and then from individuals in the OEM to a central risk champion in the OEM, was seen as a problem. The OEM saw the solution to be the use of both types of information management system to be used, which will be discussed in the following section.

5.5.13 A Combination of Pushing and Pulling Information Required

The information whether pushed or pulled was seen as important, and a balance of pushing and pulling risk information was seen as a way of identifying and mitigating supply chain disruption risk:

“Not one approach, is effective alone, you need to have a combination of approaches.”

(OEM1-Purchasing)

“I suppose individually the information means nothing but collectively it could be a big pointer.”

(OEM2-Purchasing)

“I think with the push if you could use some of these intelligent internet tools that are coming out, to filter articles from the outside world into that, because if you’re just relying on one person filling it out, it’s a lot of time and effort.”

(OEM2--Purchasing)

The importance and use of pulling risk information was seen as key, but the information overload nature of push systems was also argued to be as important.

“It’s all about going after the information yourself rather than waiting for the information to come to you because it doesn’t always come does it.”

(OEM2--Purchasing)

“There’s enough e-mails as it is.”

(OEM2-Purchasing)

“The information comes out of there, but you haven’t to go pushing... okay so you’ve got to go to it in the first place, so you’ve got to push to get the information, but once you’ve got the information, you can be ahead of the game.”

(OEM2-Purchasing)

Some did see the importance of pushing information and the DNBI tool was seen as outdated at times:

“I think it would be handy to have the information. When you go on a push and you’re pushing for that information, your pushing to get ahead of the game, what you are getting is the information or the market intelligence that is there, it’s new, it’s as it’s happening. If you rely on a pull system, a lot of the Dun and Bradstreet information that’s going to come to you, can be six months, twelve months old.”

(OEM2-Purchasing)

The nature of gathering information from suppliers was also seen as important and an aspect of the day to day role of a purchaser in the OEM.

"I think what I'm saying is that a push system, I would love to have the push system there because that's my job, I go out and I'm listening to all this stuff that's out there, but I think the push system, if you put a system in, it would have to be self-feeding site and you'd come to live with it."

(OEM2-Purchasing)

"I think it's nice to have something you could perhaps draw on, you know, for information flow, but you don't want it forced upon you."

(OEM2-Purchasing)

"We won't have the manpower to go out and attend these conferences or to network because we just don't... we don't network. It's not our culture to do networking. So the push system I guess if you get that networking information in from that somehow, that could be a benefit."

(OEM2-Purchasing)

Gathering information from push systems was seen as important but needs to be complemented by a pull system.

A balance of both forms of information systems was seen as important:

"I think if you have a system that balances both approaches"

(Academic1)

"Both systems will of course have their own limitations. You're going to be, you may be not getting all the information with a pull approach, on the push approach might be getting loads of wrong information, and gossip."

(Academic1)

"to me the answer seems fairly obvious that you want to be somewhere in the middle. In other words you need the push information like the Dun and Bradstreet, people perhaps need some of the pull, which is the social network approach perhaps, or a bit of both."

(Academic2)

A reason why the DNBi was seen as an important pull tool was to do with outsourcing information to other companies, being a trend in current supply chains:

"...Because you're putting the onus and the expense of managing the risk onto somebody else, which is the current trend in supply chain management, pay people to do that because it's easier to control your costs if you're

transferring something that's highly variable onto something that is relatively fixed, so that's why it's done."

(Academic2)

Pulling information and pushing information were both seen as important, as can be seen from this section. Individuals are equally important as to which type of information management system that they prefer. Certain individuals preferring push systems over pull systems and others arguing that pull systems are better. A consensus was reached that both types of systems compliment each other and balance of both needs to be created in the OEM to gather disruption risk information from the supply chain.

5.6 Chapter Summary

This chapter has examined the two propositions of this thesis and highlighted why the exploratory themes led to the propositions. The propositions are further explored in the focus group interviews in the OEM and Aston University. The focus groups replicated the findings of the exploratory case study, in terms of showing how important social networks are to identifying supply chain disruption risk.

The use of social networks were still tacit and not formalised, however formalising them using meetings and feedback to management was seen as one way of improving the process of risk information gathering. Push and pull were seen as important methods of risk information gathering. It was agreed that pull was better than push to avoid information overload. However a balance of the two was also favoured to identify the information flows that lead to the identification of disruption risk. The following chapter will go on to summarise the findings from the exploratory case study, supply chain perception study and the focus group interviews.

Chapter Six - Discussion of Findings

6.0 Introduction

The previous chapters have looked at the findings from the exploratory case study, and the development of research propositions for the focus groups analysis. This chapter will discuss the findings in more detail and examine each study and the key findings from each.

6.1 Exploratory Case Study

Sodhi et al. (2011) suggest that there are three “gaps” pertinent to future research in SCRM:

1. No clear consensus on the definition of SCRM;
2. Lack of commensurate research on response to supply chain risk incidents;
3. A shortage of empirical research in the area of SCRM.

The exploratory case study is empirical research in the area of SCRM. Its aim was not to give a clear definition of SCRM but try to understand SCRM from a practitioner’s perspective. Khan and Burnes (2007) suggest the use of case studies to investigate how companies manage supply chain risk and what processes that companies use to identify and analyse risk in their supply chain. The exploratory case study looked at how practitioners manage supply chain risk, and in particular, how they first identify risk in their supply chain. Galaskiewicz (2011) argues that there has been little research done into social network analysis in the supply chain, and goes on to say that social network analysis can add value to the supply chain

management literature. He argues that social network ties between organisations in the supply chain are important in building trust amongst the individuals that can therefore facilitate information exchange, cooperation and coordination.

The triggers that come into the organisation have not been discussed in any depth current literature and it was interesting to note that one interviewee suggested that a “suite of indicators” is required because each indicator or trigger goes to different departments in the OEM. Sheffi (2005) and Harland et al. (2003) mention the triggers or weakest signals, but do not explore them and give no explanations as to what they may be. A coordinated approach at looking at these triggers so that a risk can be assessed is required. A risk champion in the OEM, as discussed by Jayashankar and Brian (2007), would have gathered this information and assess the risks not only based on the triggers but also the social communication flows coming into the OEM.

Some of the triggers mentioned in the interviews were:

1. Requests for changes in payment terms
2. Missing deliveries
3. Financial reports on suppliers
4. Staff turnover, especially senior management
5. Changes in lead times
6. Unexpected price increases
7. Social network information
8. Internet or media news
9. Industry news from industry bodies

All interviewees shared the view that identifying supply chain disruption risk was important through the use of current social networks or individuals in the OEM.

Building good relationships were seen as important so that suppliers feel obliged to let you know a risk is on the horizon, but also argued was the point that when suppliers are in trouble the OEM would be last to know. Kanter (1972) argues that these forms of ties are known as moral ties where a code of fairness or reciprocity is the main binding force.

Mitchell (1995) suggests that risk reducers include; choosing a leading company in the field, using an approved list of suppliers, multiple sourcing, visiting supplier operations and establishing good communications with suppliers. This view is supported by Condon, (2007) who argues that mitigation strategies, such as having spare capacity and alternative suppliers are expensive; the better sharing of information is the key. Information is always the cheaper thing to share, rather than having spare capacity or inventory (Condon, 2007). This led to a line of enquiry in the exploratory case study regarding information, and how it is gathered through social networks.

Current perceptions of the social networks in the OEM with its suppliers suggested that everyone in the OEM has their own social network and is based on the individuals in the OEM and the suppliers. Tichy, et al. (1979), argue that a supply chain could incorporate a wide range of units of analysis and the unit of analysis at the individual level in the OEM and the suppliers was seen as important in the exploratory studies. The local suppliers have more contact with the OEM as may be expected, so the social contacts or networks are better, also the longstanding nature of the organisation in the industry means that supplier relationships have been stronger over time so that relationships are therefore better. The regularity of contact between the OEM and suppliers also aided in increasing the level of social contact and the building of social networks. This regularity would partly be due to the locality of the suppliers. Conway and Steward (2009) describe this feature of the social

network as openness, which is the degree to which the individuals are connected to other individuals in other groups and networks. The locality of suppliers and frequency of contact with the OEM, suggests that this is more of a closed network, where there are many strong ties and few weak ties. This would possibly aid in the exchange of risk information because of the strong nature of the relationships, and friendships and reciprocity (Kanter, 1972) being present. It was argued that the social contacts relationships that exist are purely work based and not based on meetings outside work or “socials”. Borgatti and Li (2009) distinguish relationships between hard and soft ties. Where the hard ties can be materials or money flows, and the soft ties can be the sharing of information or friendships. The exploratory study showed that both these types of relationships were present within the OEM, with the exchange of money and materials as well and information and friendships between individuals in the OEM and the suppliers.

It can be seen that social network intelligence was seen as important to identify risk within the supply chain but no formal processes were in place to assess these social networks. This finding is aligned to the findings of Juttner (2005) where less formalised processes and tools were found to be more popular than formalised tools. Financial checks on suppliers were ad hoc and not regularly done. The OEM was also suggested to be the last to know when a risk is on the horizon, and suppliers were not forthcoming to share risks within the supply chain. The method of contact with suppliers was also discussed by individuals in the OEM, with face to face seen as the best method followed by phone then email. These forms of contact can be seen as discrete forms of ties, where there is interaction, e.g. emails or phone calls, and also flows, e.g. information transfer (Borgatti and Li, 2009).

Mohd Nishat et al. (2006) argue that risk susceptibility is dependent on other constituents of your supply chain in their theoretical paper. They go on to stress that

information sharing and communication and coordination among all elements of the supply chain are essential to its success (Mohd Nishat et al, 2006). The notion of developing relationships between the OEM and suppliers needs to be improved, as there is no formal process which documents visits with suppliers, which does happen with visits to customers. The level of social contact and the importance of suppliers, i.e. the top five suppliers based on spend, could be cultivated better, with senior management in the OEM spending time cultivating these relationships also. The developments of these relationships were however hindered by the thoughts that the OEM cannot manage the suppliers business and the suppliers need to take ownership for their risks in the organisation also.

The depth of how far down the supply chain the social network should extend and whether risk is passed down the supply chain when outsourcing occurs was also explored in the interviews in the OEM (Bales, et al., 2004). Responses were mixed, with some interviewees saying it is difficult to extend the social network beyond the first tier, and others arguing it can be extended all the way down to the raw materials suppliers. It was also suggested that it depends on the sophistication of the first tier supplier, with the sophisticated supplier having its own social networks with its suppliers so networking further down the supply chain by the OEM is not required. There was also a common perception as to which suppliers that the OEM found to be at risk, such as forgings suppliers, electronics suppliers and bearings suppliers, but no formal process of mitigating this risk was in place. Bales et al's (2004) empirical research in the aerospace industry finds that outsourcing periphery activities has altered the shape of the supply chain. There were mixed views as to if risk is passed down the supply chain if outsourcing occurs. With some interviewees arguing that risk is passed down the supply chain, and others arguing that the risk still belongs to the OEM.

The hindrances to creating better relationships with suppliers and improving social networks were disclosure concerns with regards to public limited companies. Also ethical concerns were an issue with the views that too much social contact with suppliers isn't good, and social contact should be restricted to business issues without extending to socialising in general. Also ethics were seen as an issue when choosing a preferred supplier, and relationships shouldn't be taken into account or social offers shouldn't be included when making decisions on which supplier to choose. Communication issues were also of a concern, with the global nature of suppliers leading to less contact as compared to local suppliers. This led on to cultural issues, where cultures influence the type of communication and frequency of communication. Communication methods such as fax and email were also seen as a hindrance to communication, with face to face meetings preferred. Other issues included too much communication where the OEM can tend to manage the suppliers business and risks. Summing up, it can be seen that the OEM sees social networks and relationships with suppliers as important to managing risk in the supply chain; however, there are concerns as to flow of information and managing of the information by the OEM.

Some of the solutions to identifying and managing risk, suggested by interviewees in the OEM included regular assessment of suppliers financial stability and having supplier health checks, and improving face to face communication with suppliers, combined with regular contact whether through direct contact or through supplier and industry forums.

Key constructs to describe and to analyse social networks were discussed in Chapter 2 (Wasserman and Faust, 1996; Conway and Steward, 2009). The network of the OEM is well established between certain individuals from certain departments, so little diversity appears to exist in terms of profession. From analysing the

interviews, there seems to be well established relationships within the supply chain however this does not seem to go beyond the supply chain or from the OEM down to further tiers of the supply chain. However, it was suggested that in the future networking could increase and increase the openness of the OEM, through networking of industry bodies.

The networks with some suppliers in the supply chain are very stable due to the longevity of relationships. The small size of the OEM also leads to a more stable network due to closer relationships with suppliers. In other cases, networks are created all the time due to new suppliers becoming apart of the supply chain, and also individuals leaving the OEM or the suppliers. The network of the OEM is therefore stable in terms of longevity of relationships but also dynamic because of new suppliers and new contacts within the suppliers and the OEM. The relational ties between individuals and the OEM and suppliers were evident from the interviews (Conway and Steward, 2009). Instrumental ties are evident in terms of spend and information exchange. Affective ties in terms of friendships between individuals were apparent. However, the friendships were not seen as acceptable and contacts should be only on a work basis. Moral ties within which reciprocity was also evident, with individuals feeling obliged to go further for you, and let the OEM know about risks on the horizon (Kanter, 1972). Summing up, the interviews did show that many relational ties exist between the OEM, individuals in the OEM and suppliers and their employees.

Tang and Nurmaya, 2011, found that there was a lack of models analysing the supply chain risk associated with information flows. When analysing the interviewees' responses in the OEM in regards to communication and information flows with suppliers, a common theme that emerged was that information was being pushed into the organisation or pulled into the organisation. The literature looks at

this aspect of information flows (Edwards, et al. 2005; Damodaran and Olphert, 2000) and sees a tension between pushing and pulling and a balance is required (Holthouse, 1998). Individuals contacting the OEM employees from the suppliers regarding risk information or any social information were seen as pushing information to the OEM. Examples of information being pulled into the OEM included individuals ringing suppliers for information, analysing and searching for changes of the financial stability of suppliers. Also using trade associations and forums to pull information about suppliers was another example of pulling information.

6.2 Supplier Perceptions of Risk

Four suppliers of the OEM were identified, and were approached to be interviewed to see what their views were regarding risk in the supply chain. Two of the suppliers were forthcoming to be interviewed, one being an electronics supplier and the other being a bearings supplier. There have been few studies exploring the differing perceptions of risk along the supply chain (Brookes and Singh, 2009). The interviewees in the OEM viewed obsolescence as a risk in terms of electronics, but the interviewee in the electronics supplier saw obsolescence as not an issue since they could deal with supplying any obsolete electronics given enough notice. The bearings company suggested that the relationship with the OEM was more risky than the OEM was aware of, since it was a sole sourced supplier, and an alternative supplier that the OEM was considering was still supplied by this same supplier. So the alternative supplier was still being supplied a sub component by the existing bearings supplier. So the risk that there was a monopoly supplier in the supply chain, which was initially triggered by increasing lead times by the supplier is further compounded by the fact there was no credible alternative supplier that the OEM was aware of.

6.3 Focus Group Findings

The focus groups in the OEM and in the University, found that, as with the exploratory case study that social networks are important to identify risk but they are not formalised and very tacit in nature. The attendees in the OEM focus groups used social networks on a daily basis and saw the importance of keeping good relationships with suppliers through social contacts and networks. The loyalty of suppliers wanting to retain business with the OEM was seen as a reason for them to share risk information more readily. This was argued to be a social bond between the organisations (Hakansson and Johanson, 1990) and also a moral tie between individuals with reciprocity present (Kanter, 1972). Again suppliers were not seen as forthcoming to readily share information when they are in trouble. The automation of work and work routines, leads to less day to day contact with suppliers so was seen as a hindrance for the OEM to manage social contact with suppliers. It was recognised by all the focus groups that individuals were key to the social network in organisations. The frequency and regularity of contact with suppliers was also seen as key. This also indicated as discussed earlier that a closed network was present with suppliers (Conway and Steward, 2009).

The individuals in the OEM realised that a combination of social network risk information and risk information from more formal methods was needed, such as the DNBi tool. This is contrary to Juttner's (2005) research where less formalised tools are more popular than formalised tools in risk identification and mitigation. The nature of information could also be more formalised by way of more meetings with suppliers. Also there was formal and informal contact being shared between suppliers and the OEM. As discussed earlier, the OEM focus groups found that the

DNBi tool was a good way of obtaining facts about risk in the supply chain, and is good that it focuses on the riskiest perceived suppliers.

This leads on to the findings that predicted and routine risks were seen as more important than unknown risks. Thus a risk that may not cause too much disruption to the OEM was more important than identifying unknown risks that may cause worse disruption. Thus knowing about risks is important, but the risks that will cause big disruptions, the OEM individuals agreed to just knowing that they will have such an effect was enough. So no formal processes were in place to manage such risks. It can be seen why the DNBi tool was favoured over a theoretical social network tool since it supplies information based on which companies that the OEM thinks are its important suppliers, and this risk information is assessed. Whereas the social network tool could look at the whole supply chain and was designed to catch the unknown risks in the supply chain through triggers and social network information.

The OEM saw the need to respond to risks in the supply chain through having flexible individuals who can react to risk within the OEM, this was a factor not explored in the literature. The University focus groups found that having the right methods to identify risk was important as the people who manage the risk information. Another interesting finding from the University focus groups was that each supplier should have different methods to gather risk information, so with important suppliers the OEM should have push systems and with the less important suppliers pull systems. This selective nature of suppliers risk information management was also seen as important with regard to cultural issues and trade issues, hence when sharing information may not be culturally appropriate or may breach trade regulations.

All focus groups, as with the exploratory case study, saw the reluctance to create social networks with suppliers because of ethical issues, however such communication does take place and the attendees of the focus groups saw this as important to identify and manage supply chain disruption risk.

The importance of individuals in the OEM was also again highlighted with social networks being developed and kept by key individuals, and social networks being disrupted when key individuals leave the supplier or OEM organisations. Tichy, et al. (1979) argues that this level of social network is at the individual level as opposed to the organisational level.

One issue that was explored in the focus groups, which wasn't explored in the exploratory case study, was trust barriers to the social sharing of information. Certain information which the OEM may not want to share with suppliers and suppliers may not want to share with the OEM. Also, the concept of misinformation was discussed, and could the OEM trust the information coming to individuals in the OEM from supplier contacts. Galaskiewicz (2011) argues that social networks between organisations in the supply chain are important in building trust amongst individuals that can therefore facilitate information exchange, cooperation and coordination.

When push versus pull information was explored in the OEM and University setting, pull was seen as better than having information pushed to you for many reasons. One being it was based on the individual pulling what is required, also it avoids information overload from a push based system. However the importance of push based information was recognised as being key as it could contain important risk information.

As discussed earlier, there is a need to balance push and pull information processes (Holthouse, 1998). Again, as with the exploratory case study, individuals in the OEM may not push information into a tool such as a social network based tool because of the busy culture and time to push such information. Others argued that a combination of pushing and pulling was required for an effective risk information management approach. The importance of pushing information was understood, as to gathering information that may not otherwise be pulled by an individual, and the pull information as from the DNBi tool could be outdated at times because it is financially based.

It was also suggested by the University focus groups that the DNBi was seen as an important tool for the OEM because of the trend within the current aerospace supply chains of outsourcing peripheral activities, so that the risk management is outsourced and the onus of identifying risk is placed on someone else.

6.4 Chapter Summary

The findings of this thesis have been summarised in this chapter. The propositions of this thesis being:

- By improving information flows, through the use of social networks, we can identify supply chain disruption risk.
- The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

The findings of this chapter do confirm that the two propositions can be used to develop and formalise the risk identification processes in the OEM. Attendees of the focus groups and interviewees in the exploratory case study agreed that improving

information flows, using social networks, can identify supply chain disruption risks. They also agreed that that push and pull concepts can be used to identify supply chain disruption risk, with pull being the most favoured approach. A social network based tool would use a push type of information management approach, but OEM employees felt that this would lead to information overload and problems in getting all those involved with the tool, to actually input risk information. Pulling the required risk information combined with being satisfied with knowing about predictable risks meant that the social network tool was not a suitable approach to ascertain disruption risk by the OEM.

Chapter Seven – Conclusions/ Further Work

7.0 Introduction

This chapter concludes the thesis by looking at the contributions made by the research, in terms of theory and practice. The limitations of research are also explored followed by the opportunities for further research and practice.

7.1 Original Contribution Made by This Thesis

Phillips and Pugh. (2010) identify a list of fifteen ways in which research can be original:

1. Setting down a major piece of new information in writing for the first time;
2. Continuing a previously original piece of work;
3. Carrying out original work designed by the supervisor;
4. Providing a single original technique, observation, or result in an otherwise unoriginal but competent piece of research;
5. Having many original ideas, methods and interpretations all performed by others under the direction of the postgraduate;
6. Showing originality in testing somebody else's idea;
7. Carrying out empirical work that hasn't been done before;
8. Making a synthesis that hasn't been made before;
9. Using already known material but with a new interpretation;
10. Trying out something in Britain that has previously only been done abroad;
11. Taking a particular technique and applying it in a new area;
12. Bringing new evidence to bear on an old issue;

13. Being cross-disciplinary and using different methodologies;
14. Looking at areas that people in the discipline haven't looked at before;
15. Adding to knowledge in a way that hasn't been done before

Having explored this list, the following list was extracted from this research and indicates where this thesis is original:

1. Carrying out empirical work that hasn't been done before;
2. Being cross-disciplinary and using different methodologies;
3. Looking at areas that people in the discipline haven't looked at before;
4. Taking a particular technique and applying it in a new area;
5. Adding to knowledge in a way that hasn't been done before

Firstly, empirical work hasn't been conducted at researching the two propositions within the context of a supply chain of an organisation. There is research into supply chains and risk (Zsidisin, 2003; Chopra and Sodhi, 2004; Tomlin, 2006; Mohd Nishat et al., 2006; etc.), supply chains and social networks (Galaskiewicz, 2011; Yusoof, et al., 2011; Capo-Vicedo, et al., 2011), supply chains and information management (Jorge, 2009; Wakolbinger and Cruz, 2011), but no empirical work that combines social networks, disruptions risk and information flows analysis.

Secondly, the research is cross disciplinary in that it looks at social networks, information flows and management, and supply chain disruption risk. The research also uses a multi method approach to explore the research themes developed from interviews in the OEM, to explore the research propositions via focus groups. This has also not been done in previous empirical studies in supply chain disruption risk.

Thirdly, supply chain risk in the context of an aerospace organisation in the UK hasn't been explored in relation to the two propositions, in published literature. There is research done in the aerospace industry in the UK (Rose-Anderssen, et al., 2008; Rose-Anderssen, et al., 2011; Emiliani, 2004; Tannock, et al., 2007; Cullen and Hickman, 2001), and some mention of risks in the supply chain (Rose-Anderssen, et al., 2010). However, information flows and social networks have not been studied in terms of disruption risk in the UK aerospace industry.

Fourthly, taking a particular technique and applying it in a new area is a contribution made in this thesis. Social networks have been explored in many areas in the literature (Wathne and Heide, 2004; Cousins, et al., 2006; Lazzarini, et al., 2001), but they haven't been used to identify disruption risk in a supply chain. Information flows, in terms of push and pull have been explored in knowledge management (Edwards, et al., 2005; Damodaran and Olphert, 2000; Holthouse, 1998) and uses on the internet (Gibson, 1997; Herman, 2010), but not explored in gathering disruption risk information in a supply chain.

And as a result of these four elements, fifthly, this thesis adds to the knowledge base of supply chain risk management and supply chain management. The findings from the research can be used to further explore supply chain disruption risk in a supply chain of other industries, other than the aerospace industry.

Galaskiewicz (2011) questions what theories from social networks are particularly relevant for interdisciplinary supply chain management research. He questions more specifically, what new/emerging theories? Are there any existing theories from your field that have been overlooked by supply chain management scholars? These questions are answered by this thesis in its contribution.

This thesis began with an outline as to the conceptualisation of the research questions, which included discussions about a retrospective supply chain disruption incident in the OEM's supply chain. This was followed by a literature review which helped develop the following themes for the exploratory case study in the OEM:

- Social networks can be used to gather supply chain disruption risk information
- Supply chain disruption risk information flows can be identified by exploring triggers that identify risk through the concepts of information “push” and “pull”

The exploratory case study found that social networks are being used currently but are tacit and informal in nature. Social networks were seen as important in disruption risk identification. The triggers of risk were also received into different departments in the OEM based on differing information flows, either being pushed into the organisation or being pulled into the organisation. These findings helped develop the propositions of the thesis:

- By improving information flows, through the use of social networks, we can identify supply chain disruption risk.
- The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

Thus it was seen that by improving information flows, through the use of social networks, the OEM could identify supply chain disruption risk more readily. It was also seen that the risk triggers coming into the OEM were being either pushed or pulled. Thus the second proposition being the OEM could thus help to identify disruption risk by exploring the push and pull concepts.

7.1.1 Conclusions from the Research Propositions

The focus group investigation of the propositions, further confirmed the findings from the exploratory case study that improving the flows and making them more formalised would improve the identification of supply chain disruption risk. The importance of using social networks was identified coupled with the daily use of them by the OEM's employees; this confirmed the use of social network was important to identify supply chain disruption risk. The findings that the OEM employees would be satisfied with knowing about risks that are predictable, i.e. from a known 'risky supplier' suggests that unknown risk identification isn't important. A push type information flow would be better at identifying these unknown risks. The OEM employees however favoured a pull tool, and rather pull risk information of risks that they knew about. A balance of pushing and pulling was also suggested to best satisfy the identification thus help with the mitigation of supply chain risk.

7.1.2 Theoretical Contribution

The understanding of supply chain risk was seen as patchy and needing development in the literature review (Juttner, 2004). Since this paper many researchers have explored supply chain risk (Juttner, 2009; Juttner, 2011). However the challenge being more empirical studies needs to be conducted to understand supply chain risk further.

This thesis has explored supply chain disruption risk and used a case study approach to find two propositions that have provenance in practice and also within theory. These propositions have been explored through focus groups with a practical setting and also an academic setting. This improved the rigour and triangulation of

the research and also allowed the transfer of ideas from academia to practice and vice versa.

Three unique findings that contribute to theory on identifying supply chain disruption risk were found, the first being that predicted and routine risks are more important than unknown ones. It was found in the focus groups in the OEM, that knowing that you have a risky supplier is more important, than risks you may be unaware of in another supplier. The second key finding was the list of behavioural triggers that identify that a risk is on the horizon. The literature has touched upon these triggers (Sheffi, 2005; Harland, et al., 2003; Kleindorfer, et al., 2005), but the triggers haven't been explored in any depth in the literature. The triggers were:

1. Requests for changes in payment terms
2. Missing deliveries
3. Financial reports on suppliers
4. Staff turnover, especially senior management
5. Changes in lead times
6. Unexpected price increases
7. Social network information
8. Internet or media news
9. Industry news from industry bodies

Another key finding in the academic focus groups was that information management to identify disruption risk through push and pull methods should be based on the importance of the supplier. Thus, for the most important suppliers you would improve relationships and also have push systems to collect risk information. With the less important ones you would have pull type information systems.

The publication of six peer reviewed papers in the proceedings of POMS and EurOMA, suggests that some level of theory has been developed from this research and thesis that has had lots of interest and questions from fellow academics.

The provenance of the propositions is not only based on theory but also based on discussions about a retrospective case where there was a disruption in the supply chain of the OEM. The findings of this thesis are not only theoretical but also practical.

7.1.3. Practical Contribution

The practical findings of the research are the comparisons made of perceptions of risk along the supply chain. This suggests organisations such as the OEM needs to communicate better with their suppliers as to their concerns about disruption risk, thus allowing suppliers to provide their views on the risk. It was found in the exploratory case study, that a forum where suppliers meet the OEM could be one way of doing this. Another means would be regular meetings with individual suppliers to discuss supply chain disruption risk.

7.2 Reliability

As discussed in chapter three, the thesis needs to be explored in terms of the reliability, validity and generalisability of research.

Reliability can be assessed by posing the following three questions (Easterby-Smith et al, 2002):

1. Will the measures yield the same results on other occasions?
2. Will similar observations be reached by other observers?
3. Is there transparency in how sense was made from the raw data?

The nature of the research in terms of interviews and focus groups, is based on individual responses on the day of the research method. Subject or participant error can therefore be present as well as bias, in terms of saying what the interviewer or moderator expects to hear (Robson, 2002). Thus the same questions posed on different days by different observers, may yield different results, thus making the methods of interviews and focus groups not as reliable as maybe quantitative approaches can be. However it can be argued that even quantitative results can produce varied results based on respondent's answers on any particular day. The interviews and focus groups were conducted over a period two years, and the same questions and techniques were used during these. The answers were also consistent over time. The framework for the interviews and focus groups could be used again to produce similar answers, so the research can be seen as repeatable.

7.3 Validity

Validity is concerned with whether the findings are really what they appear to be. Kreuger, 1994, argues focus groups are valid if they are used carefully for a problem that is suitable for focus group inquiry. He continues to point out that focus groups, and to the same extent interviews, are very much like other social science measurement procedures in which validity depends not only on the procedures used but also on context. Thus the findings of the focus groups and interviews can be argued to be valid, since they based on valid theoretical methodologies (Yin, 2002, Kvale, 1996, Gibbs, 1997), as seen in chapter 3, and also conducted in an OEM

setting and an academic setting. The OEM setting allowing practitioner discussions and findings on the propositions, and the academic setting allowing expert opinion on discussing the propositions.

Focus Groups can be used either as a method in their own right or as a complement to other methods, especially for triangulation and validity checking (Morgan 1997, Kreuger 1994). The methodology of this thesis thus uses this approach to improve triangulation and validity. The interviews were conducted prior to the focus groups, to help develop the research themes into propositions. The focus groups then helped to triangulate the research findings from the interviews and explore the propositions further.

The limitations of the case study include cost, time, inability to generalise and prescribe, and potential for bias in the perceptions of the researchers (Boyer, 2008). These will be explored in the following sections.

7.4 Generalisability

This is often referred to as external validity and is the extent to which the results of research are generalisable, that is whether the findings can be applicable to other research settings, such as other organisations or industries. Stewart and Shandasani (1990), argue there are limitations on the generalisability of focus groups. This can be argued to be the case in this thesis since the OEM's attendees were all supply chain focused, so were selected based on convenience and knowledge of supply chain risks. Gibbs supports Stewarts and Shandasani's (1990) view and says focus groups are however limited in terms of their ability to generalise findings to a whole population, mainly because of the small numbers of people participating and the

likelihood that the participants will not be a representative sample. Thus the generalisability of this research is limited to the context of the OEM. However the use of academics in the focus groups, from varied backgrounds and industrial experiences, does to a certain extent make the findings more generalisable.

7.5 Interviewer/ Moderator bias

As argued by Robson (2002) observer error can be present in interviews because there can be more than one way of asking a question, and each way will spur different answers. The author of this thesis did remain impartial as possible and asking similar questions to all interviewees of the OEM exploratory case study and consequent focus groups. But observer error can never be ruled out but can be minimised since the author interviewed all the OEM exploratory case study interviewees and moderated two of the four focus groups. The same questions and framework was used for all.

Robson (2002) goes on to argue that observer bias can be present. There are different ways of interpreting the replies from an interviewee. This can be argued to be true, especially if only notes were taken of the interviews and focus groups. Bias was minimised due to the process of transcribing, coding and analysing the interviews and focus groups. However, the interpretations of the quotations can be argued to be different by different people. This does make the methods used less valid than quantitative results may be. But the richness and depth of interviews and focus groups will not be present in such quantitative results. So there is a balance in terms of validity and richness of data found from either approach.

7.6 Research Publications

During the process of this research, papers in peer reviewed conferences in the area of operations management have been published in their proceedings; these are listed in appendix J. A sample of these publications can be seen in appendices, G, H and I.

Since each of the papers are directly relevant to the research aims of this thesis, it can be argued that the research has some academic backing since the papers were peer reviewed and accepted for presentation and publication in well recognised Operations Management conferences. This process would have tested the methodologies used in this thesis as well as initial findings from the research.

7.7 Limitations of Research

The generalisability of the research is limited, because it is based in one organisation, in one industry. However, since the research was also based in supplier's organisations and within an academic setting, the generalisability is improved. The researcher did try to test the propositions by means of focus groups within the suppliers of the OEM, but was unable to do so because of the supplier's reluctance to participate in this manner.

The exploratory case study was limited by the small nature of the OEM, and the number of employees who were actually involved in the supply chain, thus have some form of social networks with suppliers. Having a broader range of interviewees would have made the research more valid. Interviewing more suppliers of the OEM

would also have helped, but this again was limited based on the reluctance to participate in the research.

The limitations of the methodology and analysis are that fewer participants were involved in the research as compared to quantitative methods. However if you summate the number of attendees of the focus groups, twenty eight participants (see table 3.6), the research can be seen as more valid and rigorous. The use of interviews coupled with focus groups also made the research more valid.

7.8 Further Research and Practice

Future research can be based in more organisations and in other industries, other than the aerospace industry. The propositions could be tested in other organisations and industries via the use of focus groups.

The methodology could also use more of a mixed approach to test the findings and propositions, via quantitative methods, a survey for example. This would improve the reliability of the findings and also the generalisability. In defence of the methodology used in this thesis, qualitative research was deeper and richer and also teased out relationships which were related to the social nature of the main research aim.

The research could help develop a social network based tool, (see appendix G) and then be tested via, for example, an action research methodology, whereby the researcher would spend time to observe the use of the tool within the organisation. This was the primary aim of the research, but the OEM was reluctant to allow time to develop and test the tool in the organisation since they had the DNBI tool and also suggested that no one would use such a tool as the social network tool in practice.

The exploratory study with the OEM's suppliers also found that there were differing views as to the perceptions of risk in the supply chain. Future research could extend this research into other suppliers (tier one) and also into different tiers of the supply chain.

7.9 Chapter Summary

The economic downturn during the time of conducting the research for this thesis hasn't helped with the access to organisations in the supply chain to conduct research, as well as access to the OEM to consult and feedback the findings of the research. Nevertheless, the thesis has been able to follow the methodology prescribed in chapter 3, to successfully gather data and analyse the data in relation to the main propositions of the thesis.

Case study research, interviews and focus groups can be seen to be limited in terms of their validity, generalisability, and reliability. However in the right context, with the right methodology based approach these three aspects of research can be improved. The author of this thesis has tried not to bring observer error or bias into the research, by using the methodology based approach to data collection, assessment and analysis. Theoretical contributions have been bolstered by the acceptance of six papers and one presentation in peer reviewed conferences in the area of Operations Management. Future publications would aim at a more practitioner setting, and present to practitioners as well as academics. A paper from this research will also be written for publication in an Operations and Management or a Supply Chain Journal.

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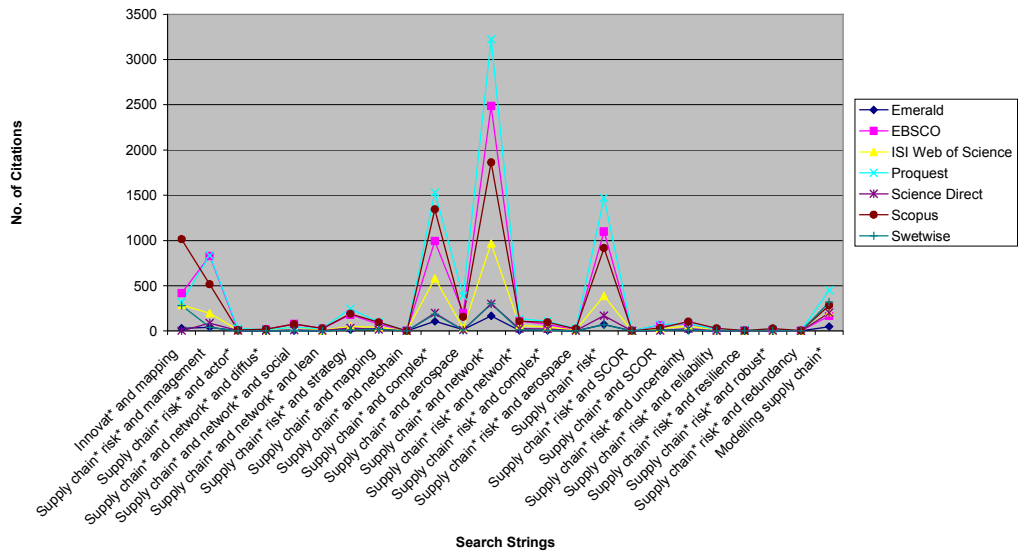
Appendices

Appendix A - Citation Statistics

Search String	Emerald	EBSCO	ISI Web of Science	Proquest	Science Direct	Scopus	Swetwise	Google
Innovat* and mapping	29	417	286	318	1	1015	281	186
Supply chain* risk* and managemen t	40	827	197	834	87	514	40	68600
Supply chain* risk* and actor*	0	8	8	26	4	10	2	12500
Supply chain* and network* and diffus*	3	19	7	13	2	17	1	158
Supply chain* and network* and social	4	79	40	38	10	73	2	42400
Supply chain* and network* and lean	1	24	6	26	3	28	0	11000
Supply chain* risk* and strategy	13	179	51	246	33	189	11	54800
Supply chain* and mapping	25	75	38	95	15	94	17	63900
Supply chain* and complex*	106	994	580	1532	198	1345	184	79100
Supply chain* and aerospace	13	197	30	386	10	156	10	12400
Supply chain* and network*	166	2487	968	3225	300	1864	299	137000
Supply chain* risk* and network*	5	109	60	134	25	108	10	44900
Supply chain* risk* and complex*	6	71	41	107	20	96	6	70100

Supply chain* risk* and aerospace	2	10	8	24	1	22	0	6600
Supply chain* risk*	71	1100	387	1470	168	916	66	11900
Supply chain* and SCOR	6	62	26	69	4	33	5	17500
Supply chain* risk* and uncertainty	7	78	55	81	25	102	9	33500
Supply chain* risk* and reliability	1	7	9	16	2	28	1	27400
Supply chain* risk* and resilience	0	8	1	11	0	3	0	6150
Supply chain* risk* and robust*	1	11	8	19	2	26	0	25500
Supply chain* risk* and redundancy	0	2	0	3	0	3	0	8110
Modelling supply chain*	48	164	205	450	201	283	318	17600
ENDNOTES	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Search Type	Abstract Keyword	Full Text	Full Text	Abstract Keyword	Abstract Keyword	Abstract Keyword	Abstract Keyword	Full Text
TOTAL CITATIONS=		721		1309		791		
1821								

Search String Analysis of Search Engines



Key strings in academic journals only

	EBSCO	Proquest	Scopus	ISI WOS
Supply chain* risk* and strategy	63	78	122	43
Supply chain* and aerospace	27	45	79	32
Supply chain* risk* and network*	26	41	69	49
Supply chain* risk* and aerospace	2	7	9	4
Supply chain* and SCOR	15	18	30	12
Total 771	133	189	309	140

Appendix B – Case Study Sample Research Questions

1. What are your thoughts on any current risks in the supply chain? (Sorensen, 2005).
2. What are the triggers that would identify a risk in the supply chain? (Sheffi, 2005, Harland 2003)
3. Do you think your company has sufficient social contacts with its suppliers? (Wausserman and Faust, 1996)
4. What are your views regarding identifying risks through a companies social contacts? (Reagans and McEvily, 2003, McEvily and Zaheer, 1999, Cross and Cummings, 2004)
5. How far down the supply chain should the social network extend? (Bale et al, 2004)
6. Do you feel risk is moved down the supply chain as products are outsourced? (Bale et al, 2004).

Appendix C - Guidelines for Moderator

1 Ground Rules

Read Informed Consent Statement (Appendix D)

Respect each others views

Allow each other to talk

Do not interrupt others

Please talk one at a time

2 Questions

What are your views regarding identifying risks through a companies social contacts

Can you give an example of a situation when a risk can be identified through social contacts

Are there any advantages of collecting risk information through a social network

Are there any limitations of collecting risk information through a social network

Which do you think is the best type of risk information management, push or pull

Which type of risk information management would you prefer, push or pull

Have you any issues you wish to discuss

Closing Session

Summarise key issues discussed

Thank you

Appendix D – Informed Consent

Informed Consent

To be read at beginning of each interview/ focus group.

I am a student at the Aston Business School in Birmingham studying for a PhD in Supply Chain Risk Management. I am conducting research looking at the risks in the supply chain of your organization.

You have been asked to participate in this interview to describe experiences in your working life at the organization, in particular describing the risks you think are apparent in the supply chain. I will ask questions that are related to supply chain risk. This is not a clinical or diagnostic interview, but purely a interview to grasp your views on the subject of risk. You may refuse to answer any questions you wish, without explanation.

The interview is confidential and your anonymity will be maintained throughout my project. I will not include any information in my thesis or any papers subsequently written about the study that will identify you.

Your participation in this interview is completely voluntary and you will not receive any compensation for your time. You may refuse to participate in this interview or discontinue participation at any time without penalty.

The interview will last approximately one hour. I would like to electronically record your responses to my questions so I can listen carefully to what you have to say and not have to take notes. I will destroy the electronic recording of this interview as soon as my thesis is completed. If you do not want me to record your responses, then I will just take notes.

If you have any questions about this project, you may contact my supervisor, Dr. Naomi Brookes at Aston Business School, Aston University, Operations and Information Management Group, Aston Triangle, Birmingham, B4 7ET.
n.j.brookes@aston.ac.uk +44 (0)121 204 3000.

Appendix E – Example Coded Supply Chain Interview

Retrospective Study and OEM's Social Contacts

With the retrospective study we were semi-tipped off only days in advance; before they advised us that there was a problem and do we need to do something.

Retrospective Study Risk Triggers

The example with retrospective study was we had no upfront knowledge it was going to happen and probably the only way of finding out about these things is through social networking, which is building a good relationship with suppliers so that they feel that they are obliged to let you know that a risk on the horizon, through a friendship basis.

For example with retrospective study, we are still waiting for an approval on alternate supply so our ability to switch to other commodities is heavily restricted compared to commercial non-aerospace markets.

Are OEMs Social Contacts Sufficient

I think we have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based so they have a UK representative.

Contacts in Supplier Companies

Personally, I haven't but our buyer would have built relationships with the companies involved. With xyz we have built a working relationship over the past two years and I hope some form of friendship is formed here through phone calls. With abc, none at all. What we do is deal with representatives one step removed from manufacturing and they are not a strong enough power within the company involved.

Current Risks in Supply Chain

There is a key risk in the rush to outsource to developing economies potentially affecting our supply base. An example might be if we have a supplier who is wholly dependent on one customer who then outsources to China; the whole of that business may go under. If we chose to outsource one or our parts to China, we may enforce the closure of that company, even the parts we didn't want to outsource.

How Far Down Supply Chain Do We Need To Manage Risk

I think it would be quite difficult to extend it beyond the first tier. Maybe the way is to encourage the supplier to do a similar type of exercise.

I think it could be quite difficult to extend the social network unless you do through third party things such as trade organisations, attending trade conferences where you tend to pick up from a wider group of people. Other organisations such as the SBAC tend to get to the many tiers of the supply base. It's more a case of building working case relationships where they let you know what's going on in advance.

Is Risk Increased as You Outsource

I think the risk as outsourcing goes on is that the risk becomes less physical. If you are no longer buying raw materials you lose control of what's happening in the raw materials market, so you are putting yourself more at risk due to lack of visibility or day to day contact.

I think it's a bit unwise/arrogant that you can pass the risks onto the supplier.

The reality is it's a shared problem. I think you do lose more contact to see the risk as the more you outsource.

Problems of Sharing Information

There is a difficulty in this which is legal issues with PLCs. If an employee discloses that a company is in difficulties, share trading issues follow on from this so you're very wary of not breaching any insider trading issues. People who are in a company that's in trouble may not also breach guidelines of that company, so there are limitations of the information that you can get that is not breaching the boundaries of legal correctness.

we don't encourage too much contact on the social side due to general ethics policy because everything needs to be kept on a reasonable business level. If a buyer spends all his time lunching with a supplier there could be questions asked. So how do you set the balance so there is a trade off between ethics policy and social networks.

You want to encourage people to interact with suppliers because of the risk issue but you don't want to breach ethical issues of becoming a preferred supplier because of social offers, but a preferred supplier because of the pricing structure. We pride ourselves in the fact that we don't have any social offers in the bidding process which may cloud our judgement. When we are a small customer of a large company that's where social networking becomes difficult. For example one of the people at XYZ told us he was retiring before it was announced in his own company. The problem with ABC is the buyer of ABC at OEM has just left, so we have to build a new relationship there.

Solutions to Mitigate Risk

That was through the social networking side; it is actually understanding the core relationships. The problem is you cannot always do that when you're at risk. I think what we need to think about is a suite of indicators.

Maybe we should have a supplier forum which is more than just a price exercise, but actually how well the business is going. What we should be thinking about is having a health check visit with critical suppliers to see how well they are operating.

Appendix F – Example Theme and Coded Text

Sample coded text for one theme extracted from Nvivo.

EXAMPLE THEME: Solutions to Mitigate Risk

EXAMPLE INTERVIEWEE

EXAMPLE % OF QUOTED INTERVIEW

<Internals\Finance Interview> - § 1 reference coded [2.14% Coverage]

Reference 1 - 2.14% Coverage

EXAMPLE CODED TEXT

“That’s where you get your risk, that’s where you have to investigate and assess those in terms of their financial stability.”

<Internals\Supply Interview> - § 2 references coded [4.24% Coverage]

Reference 1 - 2.01% Coverage

That was through the social networking side; it is actually understanding the core relationships. The problem is you cannot always do that when you’re at risk. I think what we need to think about is a suite of indicators.

Reference 2 - 2.23% Coverage

Maybe we should have a supplier forum which is more than just a price exercise, but actually how well the business is going. What we should be thinking about is having a health check visit with critical suppliers to see how well they are operating.

<Internals\MRO Interview> - § 1 reference coded [4.76% Coverage]

Reference 1 - 4.76% Coverage

It’s once you’ve had that direct contact with them, I mean over the phone is a lot better than email, I think we’re in a society now where the email is taking over. I believe the more you talk to people over the phone, or face to face, you do get better performance, so I think it’s a big thing.

<Internals\Strategic Sourcing Interview> - § 1 reference coded [6.80% Coverage]

Reference 1 - 6.80% Coverage

Having your finger on the pulse, that would go to mitigating some risk. Certainly you mentioned networking earlier, we’re all at the professional side of the industry, members of various industry bodies. As a part of that we undertake a lot of networking with our professional institutes. That’s one way we can learn where the industries are going; where there may be a risk with certain suppliers. That’s networking within the industry bodies.

Appendix G – An Initial Supply Chain Risk Pilot Study in a SME in the Aerospace Industry

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ABSTRACT

Supply Chain Risk Management (SCRM) has become a popular area of research and study in recent years. This can be highlighted by the number of peer reviewed articles that have appeared in academic literature. This coupled with the realisation by companies that SCRM strategies are required to mitigate the risks that they face, makes for challenging research questions in the field of risk management. The challenge that companies face today is not only to identify the types of risks that they face, but also to assess the indicators of risk that face them. This will allow them to mitigate that risk before any disruption to the supply chain occurs. The use of social network theory will aid in the identification of disruption risk. This paper explores an

initial pilot study looking at disruption risk in a small to medium sized enterprise (SME) in the aerospace industry.

Keywords: Supply-Chain, Risk, Disruption

INTRODUCTION

The purpose of this paper is to identify the types of risk that a small to medium sized enterprise (SME) in the aerospace industry currently faces today. This will be followed by looking at the behavioural indicators that occur in the organisation that first alert managers as to what type of risk that they may face, thus allowing them to formulate risk mitigation strategies. The views of the interviewees about their social networks will also be explored.

The paper will begin by reviewing existing literature on supply chain risk, and social network analysis. The paper will then present findings of an exploratory case study undertaken with a SME in an aerospace organisation to understand supply chain risk mitigation

MITIGATING SUPPLY CHAIN RISK: EXAMINING THE LITERATURE BASE

Supply risk is defined as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety (Zsidisin, 2003). Chopra and Sodhi (2004) go on to argue that there are nine categories of risk: Disruptions, Delays, Systems, Forecast, Intellectual Property, Procurement, Receivables, Inventory, and Capacity. This disruption can be routine and short term or catastrophic and long term. This paper will look at disruption risk in the aerospace industry. Reviewing the literature on supply chain risk, (Chopra and Sodhi, 2004, Tomlin, 2006, Mohd Nishat et al.,

2006) identifies that there are a number of tactics that can be employed to reduce disruption risk in a supply chain. These include:

- Increasing inventory
- Increasing capacity
- Acquiring redundant suppliers
- Increasing/improving communication

All of these solutions have some cost implications but increasing and improving communication has potentially the least cost implications. Reducing supply chain risk through improving the flow of information is an intuitively attractive proposition. Given the functionality of social networks in carrying information, then this paper postulates that individual's social networks could be harnessed to do this more effectively.

The proposition that social networks can be used more effectively in supply chain risk management can be seen through the widely quoted supply chain disruption in Nokia and Ericsson (Norman, 2004, Chopra and Sodhi, 2004). In this situation the same supplier risk (the burning down of a microchip factory) caused significant disruption to Ericsson, which lost \$400 million in sales, whilst Nokia used the social network of its employees to have access to much quicker notice of the disruption and therefore was able to act more quickly to mitigate against its effect.

The authors of this paper have encountered a similar situation in a case-study of supply chain disruption that they have been undertaking in the aerospace industry. A case study reviewed by the researchers of this paper in the aerospace industry found that when a company went bankrupt in the supply network of a

small to medium sized manufacturer (SME), the SME was first alerted of the imminent bankruptcy through the social network of one of its employees. Thus, it was the dyadic relationship between two actors in the supply network which allowed the SME to mitigate the risk of disruption in the supply network through more rapid and effective information flow.

The explicit mapping, analysis and shaping of individuals' social networks have been undertaken with success in a new product development context in the aerospace industry (Brookes et al., 2007). The experience of using these social network mapping and analysis techniques could be used in a supply chain context to capture relational ties between individual node actors in different supply chain organisations. These interactions would not be confined to adjacent supply chain tiers but may exist along the entire supply chain thus giving much greater advance warning of potential risk. By identifying potentially productive relational ties between actors, conduits of rapid supply chain information flows could be identified. Where no such relational ties existed, their development could be encouraged. Thus, organisations could explicitly create and maintain social networks to propagate information flow in a way to substantially mitigate their exposure to supply chain risk.

MITIGATING SUPPLY CHAIN RISK: A CASE STUDY

Semi structured interviews were conducted with a sample of SME personnel from 'stakeholder' departments namely Purchasing, Engineering, Strategic Sourcing, Operations and Finance within the SME. The interviews were 'seeded' with constructs that had been identified from the literature review as being of relevance to their experience of supply chain risk. These constructs included frameworks of risk, and the behavioural indicators or triggers that provide a first alert that there is a risk

in the supply chain. Interviewees were also asked to identify components which to them typified the types of supply chain risk that the company encountered and to explain their rationale. Interview transcripts were then content analysed to identify the emergent themes that linked interviewees experiences.

FINDINGS OF CASE STUDY

Types of risk:

The types of risk that the SME faced included:

- Increased raw material prices
- Raw material availability, due to pull from developing countries, i.e. China
- Growth and capacity related risks, lead to increased lead times
- Obsolescence risks, i.e. electronics that may no longer be available
- Sole sourced products, particularly when design authority held by supplier
- Environmental risks, i.e. flooding that can cause the shutdown of a supplier

Behavioural indicators of risk:

The authors of this paper interviewed the people at the SME and asked them to suggest possible behavioural indicators that would identify risk in their supply chain.

The indicators that were suggested were as follows:

- Suppliers asking for changes to payment terms:
“If a supplier is asking for earlier payment terms, or chasing payment earlier than normal, it’s a good indicator that there is a cash flow problem.”

(Supply Chain)

- Late deliveries

“If deliveries tend to be late, that may be because they’re unable to pay their suppliers, so they haven’t got their raw materials.”

(Supply Chain)

- Unexpected price increases

“The risks are raw material prices and also things like utility prices. They have an adverse effect on costings and competitiveness.”

(Strategic Sourcing)

- Poor quality of parts

“It could be as simple as quality has begun to go wrong.”

(Supply Chain)

- Increased lead times

“Our lead times went out from nine months to twelve months.”

(Supply Chain)

- Staff turnover

All of the information regarding the behavioural indicators was currently available to the SME. However, no formal triggers for action to mitigate these risks from the behavioural indicators were in place.

Importance of risk identification through social networks:

Furthermore, it was found that identifying risk through the organisations social network was very important. This was consolidated by the views that social networks should extend beyond the first tier supplier in order to ascertain the types of risk that the SME faced.

With respect to using social networks to identify and mitigate risk the people interviewed suggested that they are very important:

“It’s based on hard facts...but we’ve got some good solid contacts, we’ve known for a long time.”

(Purchasing)

“We’ve had to get closer to our suppliers, because we’re a smaller size.”

(Purchasing)

“Due to small size of organisation, social contacts are important”

(Supply Chain)

“The only way of finding out about these things is through social networking, which is building a good relationship with suppliers, so that they feel obliged to let you know that a risk is on the horizon.”

(Supply Chain)

Current perceptions of social networks:

The current perceptions of the social networks at the SME were described as follows:

“I think that the contact and information is a good thing, but I think it needs to be formalised, not just a series of whispers from the grapevine.”

(Finance)

“We have reasonable social contact with the local suppliers; with the more major suppliers it tends to be representative based.”

(Supply Chain)

We have “better contacts with customers than suppliers”

(Finance)

We are “not using social contacts when we could do”

(Supply Chain)

“What we ought to be thinking about is having a health check visit with critical suppliers, to see how well they’re operating.”

(Supply

Chain)

“As things begin to get more and more global, it’s (social contact) going to get more and more difficult.”

(Purchasing)

Thoughts on developing social networks:

The SME feels ambiguous about developing social networks with suppliers:

“Once you start undermining your suppliers too much, then they won’t take ownership.”

(Supply Chain)

“If we go too far we will be managing other peoples’ businesses. We should be managing our own business.”

(Supply Chain)

“You want people to interact with suppliers because of the risk issue, but you don’t want to breach ethical issues.”

(Supply Chain)

The depth of social network application:

How far down the supply chain should MABS develop its social network?

“Depends on sophistication of first tier supplier”

(Strategic Sourcing)

“All the way down to raw materials” (Operations)

“Difficult to extend it beyond first tier” (Supply Chain)

“Depends on how useful it is to the company”

(Purchasing)

“Supplier’s suppliers only” (Purchasing)

“Once you start undermining your suppliers too much, then they won’t take ownership.”

(Supply Chain)

“Depends on who the key suppliers are” (Finance)

The SME also had a common perception as to which of its suppliers that it found to be most at risk. However, no formal process of mitigating that risk was in place

CONCLUSIONS

This paper extends practitioners and the academic understanding of the SCRM issues that face a SME in the aerospace industry. This paper looks at the behavioural indicators of risk that first alert managers of risk in the supply chain, to the researchers knowledge no such study has taken place in this industry.

The literature review conducted by the researcher found no tool that combined behavioural indicators and social networks to mitigate risk in the supply chain. The use of social network theory to identify risk is thought to be a unique way of understanding the issues in SCRM that practitioners face today in the aerospace industry.

This paper has looked at the supply chain risk literature and an exploratory case study in the aerospace industry. The limitations of the study are that its provenance is based on the SME in the aerospace industry, so therefore may only be encapsulating one company’s experience. The study may also have a bias to the aerospace industry.

The authors of this paper suggest further work can be carried out that could have a focus on other industries. The issues of social networks will be core questions when exploring these industries and trying to understand risk mitigation.

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- ZSIDISIN, G. A. (2003) A grounded definition of supply risk. *Journal of Purchasing and Supply Management*, 9, 217-224.

Appendix H – Supplier Risk Relationship Management (SR²M): A Theoretical Framework

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ABSTRACT

Supply Chain Risk Management (SCRM) has become a popular area of research and study in recent years. This can be highlighted by the number of peer reviewed articles that have appeared in academic literature. This coupled with the realisation by companies that SCRM strategies are required to mitigate the risks that they face, makes for challenging research questions in the field of risk management. The challenge that companies face today is not only to identify the types of risks that they face, but also to assess the indicators of risk that face them. This will allow them to mitigate that risk before any disruption to the supply chain occurs. The use of social network theory will aid in the identification and mitigation of disruption risk. This

paper proposes the combination of social networks and behavioural risk indicators to uniquely mitigate disruption risk.

Keywords: Supply-Chain, Risk, Disruption

INTRODUCTION

The purpose of this paper is to present a tool that uses data, some of which is derived from social networks to mitigate risk in the supply chain, and to explain the provenance of the idea used in the tool. The paper will try to identify the types of risk that a small to medium sized enterprise (SME) in the aerospace industry currently faces today. This will be followed by looking at the behavioural indicators that occur in the organisation that first alert managers as to what type of risk that they may face, thus allowing them to formulate risk mitigation strategies.

This paper extends practitioners and the academic understanding of the SCRM issues that face a SME in the aerospace industry. This has allowed the researchers to develop a methodology (SR²M) that allows practitioners to develop a tool that will let them mitigate the disruption risks that they face. This tool could be a combination of human interaction and a computer based repository.

This paper will first review the existing literature base and also present the findings of an exploratory case study taken in an aerospace SME to understand supply chain risk mitigation. These ideas will then be used to develop a prototype tool which will then be presented in the paper.

MITIGATING SUPPLY CHAIN RISK: EXAMINING THE LITERATURE BASE

Supply risk is defined as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety (Zsidisin, 2003). Chopra and Sodhi (2004) go on to argue that there are nine categories of risk: Disruptions, Delays, Systems, Forecast, Intellectual Property, Procurement, Receivables, Inventory, and Capacity. This disruption can be routine and short term or catastrophic and long term. This paper will look at disruption risk in the aerospace industry. Reviewing the literature on supply chain risk, (Chopra and Sodhi, 2004, Tomlin, 2006, Mohd Nishat et al., 2006) identifies that there are a number of tactics that can be employed to reduce disruption risk in a supply chain. These include:

- Increasing inventory
- Increasing capacity
- Acquiring redundant suppliers
- Increasing/improving communication

All of these solutions have some cost implications but increasing and improving communication has potentially the least cost implications. Reducing supply chain risk through improving the flow of information is an intuitively attractive proposition. Given the functionality of social networks in carrying information, then this paper postulates that individual's social networks could be harnessed to do this more effectively.

The proposition that social networks can be used more effectively in supply chain risk management can be seen through the widely quoted supply chain disruption in Nokia and Ericsson (Norrman, 2004, Chopra and Sodhi, 2004). In this situation the same supplier risk (the burning down of a microchip factory) caused

significant disruption to Ericsson, which lost \$400 million in sales, whilst Nokia used the social network of its employees to have access to much quicker notice of the disruption and therefore was able to act more quickly to mitigate against its effect.

The authors of this paper have encountered a similar situation in a case-study of supply chain disruption that they have been undertaking in the aerospace industry. A case study reviewed by the researchers of this paper in the aerospace industry found that when a company went bankrupt in the supply network of a small to medium sized manufacturer (SME), the SME was first alerted of the imminent bankruptcy through the social network of one of its employees. Thus, it was the dyadic relationship between two actors in the supply network which allowed the SME to mitigate the risk of disruption in the supply network through more rapid and effective information flow.

The explicit mapping, analysis and shaping of individuals' social networks have been undertaken with success in a new product development context in the aerospace industry (Brookes et al., 2007). The experience of using these social network mapping and analysis techniques could be used in a supply chain context to capture relational ties between individual node actors in different supply chain organisations. These interactions would not be confined to adjacent supply chain tiers but may exist along the entire supply chain thus giving much greater advance warning of potential risk. By identifying potentially productive relational ties between actors, conduits of rapid supply chain information flows could be identified. Where no such relational ties existed, their development could be encouraged. Thus, organisations could explicitly create and maintain social networks to propagate information flow in a way to substantially mitigate their exposure to supply chain risk.

MITIGATING SUPPLY CHAIN RISK; AN EXPLORATORY CASE STUDY

The authors of this paper conducted an exploratory case study to ascertain the views of risk and risk mitigation in the aerospace SME. Semi-structured interviews were conducted with people in the aerospace SME from the following departments: operations; supply chain; purchasing; finance; engineering; and strategic sourcing. The purpose of the interviews was to shed light on the current risks that the SME faced and to find out the behavioural indicators that the SME used to identify risk in the supply chain.

The risks that the SME faced were as follows:

- Increased raw material prices
- Raw material availability, due to pull from developing countries, i.e. China
- Growth and capacity related risks, lead to increased lead times
- Obsolescence risks, i.e. electronics that may no longer be available
- Sole sourced products, particularly when design authority held by supplier
- Environmental risks, i.e. flooding that can cause the shutdown of a supplier

The authors of this paper interviewed the people at the SME and asked them to suggest possible behavioural indicators that would identify risk in their supply chain. The indicators that were suggested were as follows:

- Suppliers asking for changes to payment terms:

“If a supplier is asking for earlier payment terms, or chasing payment earlier than normal, it’s a good indicator that there is a cash flow problem.”

(Supply Chain)

- Late deliveries

“If deliveries tend to be late, that may be because they’re unable to pay their suppliers, so they haven’t got their raw materials.”

(Supply Chain)

- Unexpected price increases

“The risks are raw material prices and also things like utility prices. They have an adverse effect on costings and competitiveness.”

(Strategic Sourcing)

- Poor quality of parts

“It could be as simple as quality has begun to go wrong.”

(Supply Chain)

- Increased lead times

“Our lead times went out from nine months to twelve months.”

(Supply Chain)

- Staff turnover

All of the data for these triggers were available to the SME; however this information was not currently used to identify risk in the supply chain. Furthermore, the SME has a current perception of who is risky in the supply chain; however, there are no action processes that have taken place that mitigates the risks in the supply chain.

With respect to using social networks to identify and mitigate risk the people interviewed suggested that they are very important:

“It’s based on hard facts...but we’ve got some good solid contacts, we’ve known for a long time.”

(Purchasing)

“We’ve had to get closer to our suppliers, because we’re a smaller size.”

(Purchasing)

“Due to small size of organisation, social contacts are important”

(Supply Chain)

“The only way of finding out about these things is through social networking, which is building a good relationship with suppliers, so that they feel obliged to let you know that a risk is on the horizon.”

(Supply Chain)

MITIGATING SUPPLY CHAIN RISK: A PROTOTYPE TOOL

Indicators to identify risk, as discussed earlier, are not always fed to same person or department i.e. they are received separately by finance, purchasing, quality control etc. A suite of indicators are needed, as identified by the SME, and a system of recognising indicators and gathering information. This would include sample social networks from which information may be gained.

The SME was found to have a common perception as to which of its suppliers were most at risk. However, no formal process of mitigating that risk was in place. Furthermore, it was found that identifying risk through the organisations social networks was very important. A process of supplier risk relationship management (SR²M) was proposed to the organisation in order for it to identify and mitigate the risks it faced as identified by the behavioural indicators and social networks.

SR²M=Critical Supply Information+Processes+Triggers

Thus, the critical supply information would include the behavioural indicators, as discussed earlier, the processes would include the social networks that exist in

the organisation, and the triggers would include the points to action when a risk is found through the processes and critical supply information.

The tool can be seen in a diagrammatic form in figure 1 below.

The origin of the tool can be seen to be in the literature where papers have tried to develop tools for managing supply risk. Early supplier involvement (ESI) (George and Michael, 2005) may be a useful tool for managing supply risk. Another paper (Richard, 2002) explores the issue of risk through enterprise risk management (ERM) which focuses on proactively managing risk across organisations, encompassing strategic, operational, reputation, regulatory and information risks. Chopra and Sodhi (2004) argue that there is a need for managers to understand the variety and interconnectedness of supply-chain risks. This paper (Christopher and Peck, 2004) suggests ways to build resilient supply chains. Supply chain risks should be identified and managed. They suggest that engineered supply chains improved resilience. One very effective analysis technique that provides a strong framework for implementing a cogent risk management strategy is known as probabilistic risk analysis (PRA) (Jablonowski, 1996). Another method of analyzing risk is Enterprise risk management (ERM), which provides a framework for analyzing and confronting risks, is a practice now widely accepted by business managers (Janice, 2006). This paper (Lubka, 2002) points out that risk identification is investigated as a basic stage in risk management. Also, a classification of risk sources - physical, social, political, operational, economic, legal and cognitive environment - is proposed.

An analysis of case study data (George, 2003) suggests that supply risk is perceived by the effect that purchased items and services have on corporate profitability, market factors, and supplier characteristics. By understanding the

characteristics of supply risk, supply management professionals can implement strategies for better managing that risk. Another paper (Richardson, 2006) discusses aspects of managing the risk of a company's supply chain. Identifying where the company is at risk is the first step in managing risk. A company needs to be aware of the risk factors in a broad range of business decisions. This paper (Ding et al., 2004) presents a newly developed toolbox "ONE" to support decision makers for the assessment, design and improvement of supply chain networks. The toolbox comprises innovative and user-friendly concepts related to the modeling, simulation and optimization of enterprise networks by additionally taking into account social and environmental impacts as well as uncertainty and risk that are always inherent within modern enterprise networks.

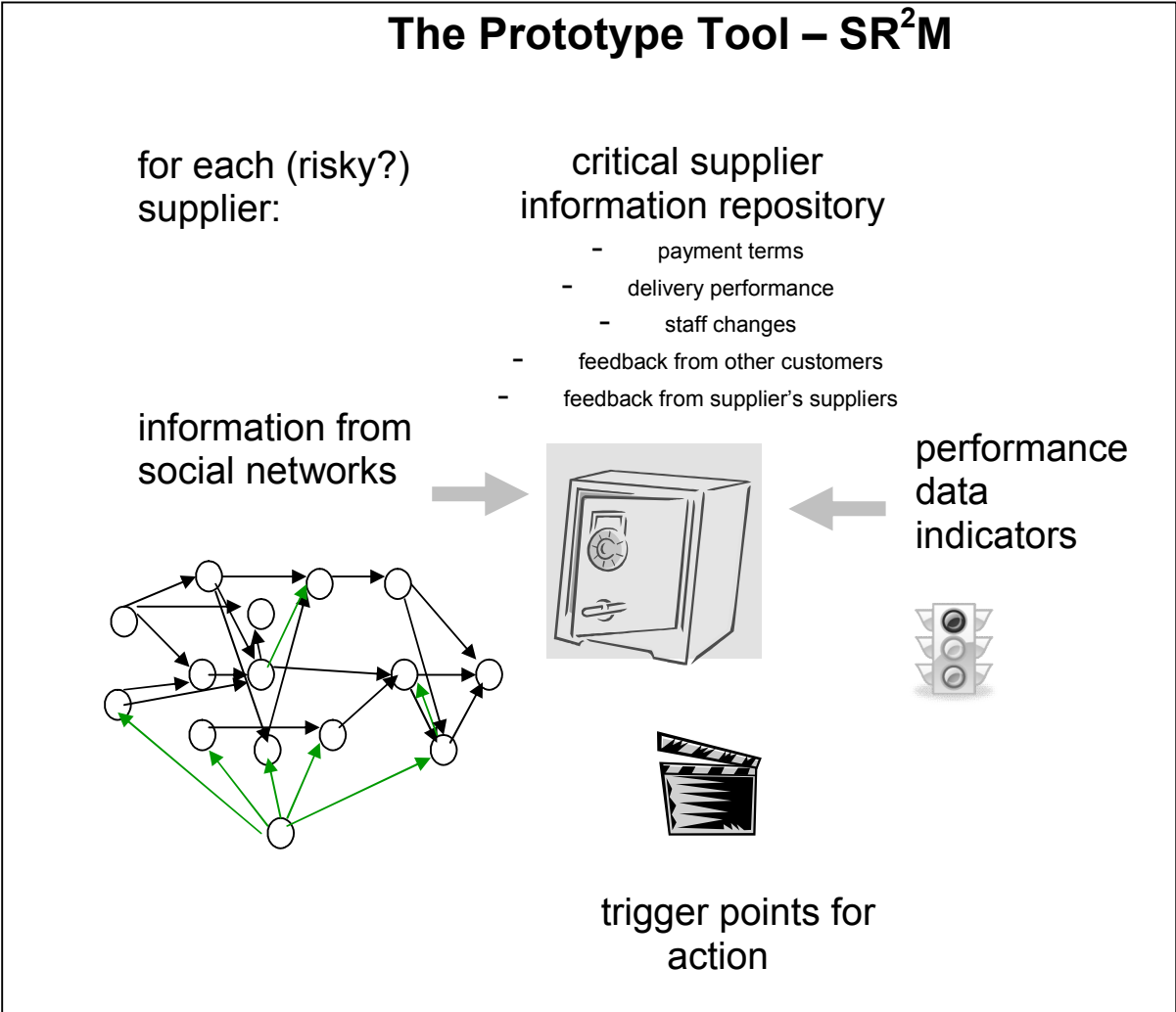


Figure 1 - The Prototype Tool - SR²M

Having reviewed the tools available to manage risk in the literature, our prototype tool is unique in that it uses data from social networks and behavioural indicators of risk, to create warning points as to when to mitigate a risk. The exploratory case study has showed us that there are behavioural triggers that would let us know when a risk is on the horizon. The Nokia and Ericsson case informed us that social networks are valuable in mitigating risk. The prototype tool uses both these sets of data to mitigate risk.

CONCLUSION

The case study found that it not just the case of collecting the indicators to identify risk in the supply chain, there needs to be trigger points of when to take action. The majority of interviewees in the exploratory case study agreed certain suppliers were a risk however no action has been taken to mitigate that risk.

Supplier risk relationship management has to be the key to identifying and managing disruption risk. Our prototype tool will help us to achieve this. The combination of using social networks, and behavioural indicators of risk will uniquely be able to identify and mitigate the disruption risk that is prevalent in the supply chain of the SME. This will only work if the trigger points for action let the SME know when a risk is visible enough for the SME to take action to mitigate for it.

The tool could be a combination of human interaction and a computer based repository. There needs to be a single portal or repository where all the information is stored and from where the trigger points for action can be identified.

This paper has looked at the supply chain risk literature and an exploratory case study in the aerospace industry, to develop a prototype tool which will aid in the mitigation of disruption risk in the supply chain. The limitations of the tool are that its provenance is based on the SME in the aerospace industry, so therefore may only be encapsulating one company's experience. The tool may also have a bias to the aerospace industry.

The authors of this paper suggest further work can be carried out to develop similar tools that have a focus on other industries. The use of social networks and behavioural indicators will be the key to developing such tools.

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Appendice I - The management of information to identify supply chain disruption risk can be explored using push and pull concepts.

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1.0 Introduction and Overview

Supply Chain Risk Management (SCRM) has become a popular area of research and study. This coupled with the realisation by companies that SCRM strategies are required to mitigate the risks that they face, makes for challenging research questions. The strategy is not only to identify the types of risks that they face, but also to assess the management of information that allow them to gather information which will allow them to mitigate that risk before any disruption to the supply chain occurs. Information management (IM) is the collection and management of information from one or more sources and the distribution of that information to one

or more audiences. The case study methodology was used for these investigations, which consisted of exploratory interviews followed by two focus groups. These were conducted within an aerospace organisation to assess the views of individuals on whether the organisation should use a push or pull information management system with regard to gathering information for SCRM.

The paper begins by giving a brief overview on the literature on supply chain risk, information management and the lack of coverage of push and pull risk information across the supply chain. It presents the results of a case study investigation.

2.0 Literature Review

The literature highlights good communication and relationship management are important factors in reducing supply chain risk (Mitchell, 1995; Condon, 2007, Juttner, 2005; Juttner, et al, 2003; Zsidisin, 2000; Khan and Burnes, 2007). However, little research has been done on actually examining the information flows that lead to risk. This point is particularly important since literature suggests that most strategies to identify and mitigate supply chain risk are expensive, i.e. to reduce risk one can build buffers in all interfaces to other companies, but doing so is expensive in the short run (Sorenson (2005). "The better sharing of information is the key. Information is always the cheaper thing to share, rather than having spare capacity or inventory." (Condon, 2007). Mohd Nishwant, Banwet et al. (2006) stress that information sharing, communication and coordination among all elements of the supply chain are essential to its success.

The social aspects of a supply chain were mentioned by a few writers, such as Kasi (2005) and Burgess and Singh (2006) as not being modelled by current methodologies for analysing supply chains, such as the Supply Chain Operational

Reference Model (SCOR). This finding combined with the better use of information to identify and mitigate risk, suggest that social network analysis can be important to identifying and mitigating risk. Social networks are important in transferring information as summarized by (Wasserman and Faust, 1996). Considering supply chains as a network of relationships (Harland, 1996) leads us to believe that social networks are particularly important in the context of supply chains. The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors allow the transfer of resources: physical or information based.

The proposition that social networks can be used more effectively in supply chain risk management can be seen through the widely quoted supply chain disruption in Nokia and Ericsson (Norrman, 2004, Chopra and Sodhi, 2004). In this situation the same supplier risk (the burning down of a microchip factory) caused significant disruption to Ericsson, which lost \$400 million in sales, whilst Nokia used the social network of its employees to have access to much quicker notice of the disruption and therefore was able to act more quickly to mitigate against its effect.

2.1 Information and Knowledge Management

Gibson (1997) suggests that within news gathering, that many users still prefer a pull type information approach, rather than being pushed daily information. However, research in a number of news organisations, suggests that there needs to be a combination of push and pull type information feeds to cater for the different needs of individuals. Malhotra (2005), researches how integrating knowledge management strategy and technologies in business processes for successful performance. The research suggests that there is a superiority of strategy-pull models made feasible by

new plug and play information and communication strategies, over the traditional technology push models. The research suggests that the propositions “getting the right information to the right person at the right time” needs to be addressed alongside, the question of what knowledge to manage and towards what end.

Edwards, et al (2005) explores the role of technology in knowledge management in organisations, both actual and desired. Findings of empirical research found that organisations need to resolve four tensions:

- Between the quantity and quality of information/knowledge
- Between centralised and decentralised organisation
- Between head office and organisational knowledge
- Between push and pull processes

The tension between pushing information and knowledge out to people or leaving them to pull it when needed. There was general agreement, in the research, that universal push systems did not work. Other literature supports this, such as Damodaran and Olphert (2000). Holtshouse (1998) suggests the need to balance push and pull approaches. Certain people are more likely to choose to pull knowledge for themselves, than others are. The research questions, how do you involve those who might least wish to be involved

2.2 Online research

On the internet (Herman, 2010), there are two ways in which information can flow from source to consumer:

Information Pull, where a consumer or user takes (or is given) the initiative to get it;

or

Information Push, where a supplier takes (or is given) the initiative to deliver it.

From the early days of the Internet up until now, Information Pull has been the most dominant force in the information market. A few years ago, this meant that consumers of information would take the initiative to visit a site/to get information. They got there by casual browsing the Net, because it was recommended by someone else (e.g. in a Usenet article), or by some other way. As the number of sites and services on the Internet began to rise dramatically, Information Pull - in this form - began to lose its appeal and power as it became too time-consuming and too laborious. As search engines and directory services (such as Yahoo) appeared on the Internet, they were able to restore most of Information Pull's appeal, but this effect is now gradually wearing off.

Information Push in the form of Push Technology arrived on the Internet in the form of such applications as *PointCast* and *BackWeb*. Its promise was to offer a strong alternative to information pull, and the not-so user-friendly search engines. Until today, Push Technology has not been able to live up to all of its expectations and claims. Although it is not completely "dead", as a number of online news papers have written, Push Technology has become more of a niche product. It can be interesting for certain groups of people, and Push capabilities are (being) built into numerous applications and services (e.g. many Web sites use it to keep their readers in touch with what has changed on or what has been added to their site). Yet, it has not been able to become the dominant way of getting information online. However, Information Push, in general is quite popular, at least in the form of mailing-list; using mailing-lists only require an e-mail program to use them, and the

information as received through them usually does not contain a lot of noise (such as 'spam') or other irrelevant information (Herman, 2010).

2.3 Summary

Research within the areas of knowledge management and information management, suggests that:

- Pull type of information management is more popular than push
- Universal push types of systems do not work
- There is a need to balance push and pull approaches
- Certain people are more likely to choose to pull knowledge for themselves, than others are, dependent on their needs
- How do you involve those who might least wish to be involved.
- Many suppliers of push type of information still have to depend on their own creativity to reach the right users

3.0 Implications on Supply Chain Disruption Risk Information Management

Social network information can be used in both a push and pull basis to identify risk. The question that arises is, similar to that regarding knowledge and information management, online and in general, is that which the most appropriate form of information management is.

As discussed earlier, this will depend on the merits of each type of information delivery system, and the type of information, as well as the preference and need of the recipient of the information.

The exploratory interviews that were undertaken at the organisation, helped develop the theoretical SR²M tool, which then allowed the analysis of the tool and a comparison to be made with the DNBi tool. The main finding of an interview with the procurement manager found that the input of information in the push type of SR²M tool was dependent on the individual users. So, the actual process of whether a push or pull type of information management, was not an issue, but the individual's motivations and need to input information into the system was an issue.

4.0 Investigation Methodology

4.1 The Rationale for a Case Study Approach

The lack of extant literature in this area meant that this investigation was highly exploratory in nature. In these circumstances, case study enquiry is a particularly pertinent research methodology. The case study enquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points. (Yin, 2002).

4.2 The Case Study Design

The context for the case study was the aerospace sector. The aerospace sector was selected as a useful environment to investigate supply chain risk as many of the perceived supply risk factors are very prevalent in the aerospace industry. These include scarcity of esoteric raw materials, low volumes, high complexity of components and a high number of 'monopoly' suppliers. The aerospace OEM that is the subject of this investigation is a wholly-owned subsidiary of a parent organisation that has a UK head-quarter but has substantial global subsidiaries including a large number of facilities and subsidiaries in the US. The OEM's parent company was ranked in the global 'top twenty' by turnover of aerospace organisations.

Fifteen exploratory interviews were conducted, lasting about an hour each, followed by two focus groups conducted at the aerospace manufacturer. This was followed by two academic focus groups conducted at Aston University. The focus groups lasted about two hours each. The interview and focus group sessions were then transcribed and analysed to identify the emergent themes that linked attendee's experiences.

5.0 Results and Analysis

Two of the questions asked in the focus groups were:

Discuss and analyse ways of improving risk management in the supply chain, through the discussion of social networks

Discuss the ideal position of an organisation, in terms of push and pull concepts

It was found throughout the investigation that Pull IM was better than Push IM, to avoid information overload:

“If you've got more of a push situation, you are going to be inundated with e-mails and enquiries.”

“I just thought if we could pull more information it would help us out beforehand.”

It was also suggested that a combination of pushing and pulling information is required:

“I think it would be handy to have both types of information. When you go on a push...what you are getting is the information or the market intelligence that is there, it's new, it is as its happening. If you rely on a pull system, a lot of the financial information that's going to come to you can be six months, twelve months old.”

It was generally agreed that a balance of push and pull information management was needed to identify risk in the supply chain. A preference was given to pulling information as it is easier to handle the volume of information and does not require wading through vast amounts of information to ascertain what was important. The attendees of the focus groups did recognise that vital information for risk identification could be missed if only using a pull system, since pull is based on knowing what you are looking for, whereas information push provides all information, of which there may be an important piece that highlights a risk on the horizon.

6.0 Conclusions

The investigations found that supply chain risk information management was identified as an area of improvement. Furthermore, findings from exploratory case studies:

- The triggers to identify risk were received into different departments of the organisation. The management of this information needs to further explored.
- An emerging theme was when analysing the triggers to identify risk, information can be pushed or pulled into the organisation.
- The push and pull concept can be used to explore the management of supply chain disruption risk in the organisation

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Appendix J – List of Publications

Singh, A., Bennett, D. April 2011. The management of information to identify supply chain disruption risk can be explored using push and pull concepts. POMS Reno, USA.

Singh, A., Bennett, D. May 2010. Predicted and Routine Supply Chain Risks are More Important than Unknown Risks: Managerial Perspectives on Supply Chain Disruption Risk. (Presentation only). POMS Vancouver, Canada.

Brookes, N., Singh, A. May 2009. A comparison of supply chain risk perceptions in Original Equipment Manufacturers and Tier One suppliers: A case-study in the aerospace industry. POMS Florida, USA.

Singh, A., Brookes, N. June 2009. An evaluation of supply chain risk management tools used by a manufacturer in the aerospace industry. EurOMA Gothenburg, Sweden.

Brookes, N., Singh, A. May 2008. Social Networks and Supply Chains. POMS San Diego, USA.

Singh, A., Brookes, N. June 2008. An Initial Supply Chain Risk Pilot Study In A SME In The Aerospace Industry. EurOMA Groningen, Netherlands.

Singh, A., Brookes, N. August 2008. Supplier Risk Relationship Management (SR²M): A Theoretical Framework. World POM Tokyo, Japan.