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Collaborating risks evaluation and management for small and medium size enterprises in virtual organisations

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Collaboration Risk Evaluation and Management for Small and Medium Size Enterprises in Virtual Organisations

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Dedication

To the loving memory of my mother

To my father who support and wait

To my brothers and sisters and their families

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Abstract

SMEs in the 21 century have to cope with an increasingly dynamic and competitive environment. In order to work effectively within this environment, SMEs have to collaborate with other enterprises in forms of virtual organisations.

Despite the increased interest in the area of virtual organisation collaboration, useful information is still lacking about the risk sources of virtual organisation, where the enterprise face more complicated risk threats than those in traditional enterprise due to the new form of relationships between partners.

The aim of this research was to identify a risk management contribution where this research has identified key areas of risk that SMEs are likely to face when working collaboratively in VO. It also enables SMEs to understand the relative importance of these risks. A further contribution is made by use of tools (ISM and ANP) to enable SMEs to understand the inter-relationships of risk sources. Multiple analysis techniques provide triangulation of analysis results, leading to validation of results.

The secondary research showed all of the risk sources identified in the relevant literature and some of the relationships between them, whilst the primary research addressed all of the direct and indirect relationships using the Interpretive Structural Modeling. Also the primary data sources from the questionnaires and the case study shed light on the relative importance of these sources using the Analytical Network Process.

Areas for further research are suggested to close the gaps and to continue enriching the research.

Declaration

This thesis contains some materials that the author has used before, and that has been published in a refereed conference paper:

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Chapter 1 Introduction and Overview

1.1 Introduction

SMEs in the 21st century have to cope with an increasingly dynamic and competitive environment. In order to work effectively within this environment, SMEs have to seek to apply a variety of principles: one of the umbrellas under which they group is the virtual organisation (VO). Such enterprise networking has caused changes in the economic environment. One single enterprise does not on its own produce the whole end product or the complete service. This also affects the investment decision-making procedures in different parts of the network; the necessary resources and capabilities are divided among many enterprises. Despite the increased interest in the area of VO collaboration, useful information is still lacking about the risks sources of this more scattered way of organising economic activity. It is important that every partner within the network should understand the possibility of failure and develop strategies and methods for risk management.

Enhanced sharing of knowledge, together with dynamic access, control and security, accelerates and improves network decision making, shortens time to market and reduces network operating costs, whilst improved capture and especially re-use of enterprise and network knowledge reduces the cost of repeating work of earlier projects, and of repeating past errors. Improved, risk aware decision making reduces the costs of wrong decisions, and failed collaborations.

Along with their numerous advantages, VOs also pose several challenges, including risks which are studied through a review of literature where thirteen risk sources were found in the network related risks of the VO. These are the main focus and include:

1. Lack of trust between partners.
2. Inadequate collaboration agreements.
3. Heterogeneity of partners.
4. Ontology differences.
5. Structure and design.
6. Loss of communication between partners.

7. Culture differences.
8. Bidding for several virtual organisations at the same time.
9. Lack of information sharing between partners.
10. Lack of top management commitment.
11. Lack of knowledge about risks.
12. Wrong partner/s selection.
13. Geographic location.

1.2 Aim and Objectives

After carrying general literature review of the knowledge management requirements for SMEs and collaborative networks, risk management was identified as a major requirement, where there was a lack of related research. Having identified this research gap and requirements, the research aim and objectives have been identified.

This research aims to identify risks inherent in collaboration between SMEs, and the relationships between these risks' sources, to analyse the potential impact of these risks, and to demonstrate contribution for the evaluation of risk to individual SMEs as propagated through the VO so as to provide a basis for effective risk management.

Objectives:

1. To conduct a comprehensive literature study of VOs including definitions, concepts and characteristics.
2. To carry out a review of current literature relating to research on SME collaboration, risks inherent in collaboration, and potentially useful tools and techniques in knowledge management, risk analysis and risk management.
3. To investigate, identify and categorise the risks inherent in formation and operation of virtual organisations due to the relationships between virtual organisation partners, often called the network level risks.
4. To map the relationships between the risk sources using the ISM (Interpretive Structural Modelling).
5. To weight the importance of the sources using the ANP (Analytical Network Process).

6. To demonstrate the application of the developed risk management contribution on a case study using a real VO.

1.3 Thesis Structure

This thesis consists of 10 chapters. A brief description of each chapter is given below.

Chapter 2: Virtual Organisation Literature Review.
This chapter contains discussions drawing on the VO literature. It begins with definitions of VO and then proceeds to examine the primary and secondary characteristics of VOs before tracing the VO life cycle by examining the viewpoints of a number of authors. After this comparisons will be made between the virtual organisation, the supply chain and extended enterprise.

Chapter 3: Risk Literature Review.
The purpose of this chapter is to contribute to a more complete understanding of risk management in virtual organisations**.** It has also emerged in this study that most enterprises operate within various networks and each enterprise sees risks in a different manner. Also, it can be said that since the enterprises are dependent on each other, risk transfer and sharing inevitably occur in the VO. An increase in dependency between enterprises may mean that they are more exposed to the existing risks of other enterprises.

Chapter 4: Methodology.
This chapter is divided into two parts. The first part is concerned with investigating the research method used to complete this research, including the research strategy and data collection methods. The other part is concerned with analysing the questionnaires. The questions were designed based on the secondary research and the models were developed after exploring the facts that emerged from the primary and secondary investigations.

Chapter 5: Risk Sources Identification in Virtual Organisation.
Risk sources in the VO have been identified from various authors who have researched and written on this issue. In this chapter, after examining the literature carefully thirteen risk sources were found under the risks and barriers categories (see

section 1.1 above), with the consequences results of these risks being failure to meet delivery time, cost and quality targets or total failure for the collaboration.

This chapter is a comprehensive study, the purpose of which is to identify these threats and subsequently to gain a better understanding by going through them one by one using the literature and previous studies. Subsequently these sources will be evaluated and ranked based on the qualitative study.

Chapter 6: Interpretive Structural Modeling.

The aim of this chapter is to explore various risk sources in the VO to establish a relationship between aspects of these risks and to classify these risks depending upon their driving and dependence power through the use of Interpretive Structural Modeling (ISM) methodology. This is a well established methodology for identifying and summarising the relationships among specific items which define a problem or an issue (Sage, 1977; Warfield, 2005). The proposed model provides a useful tool for SMEs to focus on those risk sources that are most important for effective risk management in a VO. Understanding the risk sources and their relationships will help organisations address them or at least understand them so that they can plan for them if and when they occur.

Chapter 7: Analytical Network Process.

This chapter will discuss the benefits and advantages of AHP/ANP over the other Multi-Criteria Decision Methods (MCDM) before discussing the Analytical Hierarchy Process (AHP) and the Analytical Network Process (ANP) methods and the advantages of ANP over the AHP. This will be followed by illustrations of how ANP can be used to assess risk sources as part of the contribution to facilitate and support the final decision of VO collaboration. Overall, insights from the research and the process suggested in this research will aid SMEs in making a less risky decision.

This chapter aims to reinforce the proposal for an integrated methodology to classify, manage and assess network level risk sources in VO. A risk source classification structure will be created as well as an ANP method with enhanced consistency which will rank risk sources for collaboration. ANP will then be used to set up a panel of weights of risk sources to help to define which risks are more serious, establishing the priorities for managing risks in order to find the best alternative.

Chapter 8: Case Study.

This chapter aims to develop a deeper understanding of the main constructs of risk sources in VO, especially their dependencies and weights. The review of the literature and early steps to develop the research contribution has been included prior to this case study.

A case study method (Yin, 1994) has been used to explore the studied phenomena more thoroughly. The case study method is especially suitable in situations where the purpose is to gain a deeper understanding of the research subject. Our data was gathered mainly through in-depth interviews with two managers who represent their enterprises. The case study enterprise was screened initially through a face-to-face interview and e-mails. Information gathering techniques implemented during the execution of the case study included obtaining historical data, documentation and conducting structured interviews.

Chapter 9: Discussion and Findings.

The aim of this chapter is to draw all of the key elements together in a discussion to gain a better understanding of the research results. The analysis of these data produced significant results which need to be discussed and interpreted accurately to achieve the research aims. This discussion is linked to the aims and objectives of the research and is also linked to the related literature.

Chapter 10: Conclusion.

In this chapter conclusions are drawn in relation to the work described in the previous chapters. Future work that could be carried out to build on the present knowledge is also discussed in this chapter, table (1-1) below summarises which objectives are addressed by each chapter.

Table 1-1 Relation between Objectives and Thesis Chapters

	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Chapter 9	Chapter 10
First objective	**Introduction and Overview**	**X**							**Discussion and Findings**	**Conclusion**
Second objective		**X**	**X**							
Third objective				**X**	**X**					
Fourth objective				**X**		**X**				
Five objective				**X**			**X**			
Sixth objective				**X**				**X**		

Chapter 2 Virtual Organisation Literature Review

2.1 Introduction

This chapter reviews literature covering a wide range of collaborative networks before examining the similarities and differences between the virtual organisation, the supply chain and the extended enterprise in identifying the risks associated with all types of collaborative networks. Covering this wide area will identify a more comprehensive initial list of risk sources that would have been possible by only studying literature review relating to virtual organisation.

To meet their business objectives, enterprises need to collaborate with other enterprises. Enterprises, both large and small, need to establish cooperation agreements with other enterprises. Particularly for Small and Medium sized Enterprises (SMEs) the ability to synergise with others allows them to specialise in core activities which in turn raises their added value. For SMEs the joining of forces ensures they remain competitive in the current market.

According to Li et al. (2006) enterprises need to collaborate in order to compete. Generating new revenue or new revenue streams rely upon the enterprise being able to move quickly and flexibly on proposed business ideas. This research will refer to the grouping of enterprises as a "virtual organisation".

A virtual organisation is defined by the Enterprise Interoperability Research Roadmap as "Generally, a grouping of legally distinct or related enterprises coming together to exploit a particular product or service opportunity, collaborating closely whilst still remaining independent and potentially competing in other markets or even with other products/services in the same market" (Li et al., 2006).

There are various descriptions of virtual organisations (Camarinha-Matos and Afsarmanesh, 1997; Fuehrer and Ashkanasy, 1998; Travica, 1997). The general understanding is a group of separately independent enterprises spread geographically who will share core competencies, information, finances and abilities in order to create greater opportunities for profit. The term 'enterprise partnership' is fluid in that

it describes a co-operative relationship between any independent enterprises from government agencies to the academic sector (Mariotti, 1996).

Virtual organisations were initially referred to as virtual companies, virtual enterprises or virtual corporations. These terms were first introduced in the work of Nagel and Dove (1991) and Davidow and Malone (1992) in the early 1990's. Their ideas were presented in "The Virtual Corporation", (Davidow and Malone, 1992) first introduced with new idea of an ideal virtual product which they described as being "instantly produced and customised in response to customer demand". Despite so much literature produced by the ICT and management communities there is yet to be a fixed definition for a VO that is universally agreed upon.

Working examples of virtual organisations are especially prolific in Europe where we find diverse enterprises collaborating at a regional level. Many important industrial corporations e.g. car companies, rely on "virtual" business links with corporate customers and suppliers. Whilst many activities continue to be carried out manually, ICT enable a higher level of integration. The advent of European integration has opened up a "culture of co-operation" with Small and Medium size Enterprises (SMEs) making up the majority of the European business landscape. As such the need to join forces in order to compete in a turbulent market is paramount (Camarinha-Matos and Afsarmanesh, 2005).

2.2 Virtual Organisation Definitions

Definitions offered are used interchangeably and include virtual enterprise, extended enterprise, network organisation etc…, although these definitions had received intensive attention lots of different definitions and concepts were noted. This research took the form of the literature review to uncover a definition of VO.

"The virtual organisation is a dynamic organisational tool for agile competitors". (Goldman et al., 1995).

A virtual organisation structure is described as an alliance of core competencies distributed throughout separate entities co-operating under an umbrella enterprise or group of independent enterprises.

There is a need to establish solution products that continue to develop alongside demands of the marketplace. This requires evolution of resource requirements and means the virtual organisations' associates will change according to whose competencies are needed to increase value and profitability.

As described in DeSanctis and Monge (1998) "a virtual organisation is a collection of geographically distributed functionally and/or culturally diverse entities that are linked by electronic forms of communication and rely on lateral, dynamic relationships for coordination".

A virtual enterprise is a particular case of virtual organisation, typical definitions of virtual enterprise being as follows:

"A virtual enterprise is a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunism, and whose co-operation is supported by computer networks" (Camarinha-Matos and Afsarmanesh, 1999).

"A virtual enterprise is an organisation fundamentally customer-oriented which accomplishes the customer needs in a particular way and which is extremely time and cost effective"(Davidow and Malone, 1992).

"A virtual corporation is a temporary network of independent companies, suppliers, customers, even rivals linked by Information Technology (IT) to share skills, costs and access to one another's markets. It will have neither central office nor organisation chart. It will have no hierarchy, no vertical integration" (Byrne, 1993).

Fuehrer and Ashkanasy (1998) also refers to the vertical integration of independent institutions who work together solely by means of ICT, unifying core competencies and behaving as one unit. Travica (1997) refers to geographically separate groups reliant on communicating electronically for the process of production. Raffaini (2001) defines it as non-competitive companies accomplishing a common goal without losing autonomy. Davidow and Malone (1992) view the virtual organisation as a key tool for revitalising the marketplace in the 21st century.

Using a global supply chain as an example, companies have to co-ordinate systems internally with other enterprises in the chain to create a single product whilst still

engaging in many other relationships with virtual enterprises (Moller, 1996). A global assembly of autonomous groups linked to serve specific customers is the next generation of manufacturing enterprise (IMS, 1996).

Forbairt (1996) depicted the virtual enterprise as a response to the globalisation of the digital age. He describes a virtual enterprise as a collection of specific skills and competencies to produce a particular product or service without physical head office or centre. The dissolution of the virtual enterprise is in direct response to the lack of interest in the product, and members adapt to new opportunities and so create alternative relationships to maximise advantages.

Although without a generally accepted definition, the main characteristic of a virtual organisation is the ability to create alliances quickly in order to exploit new opportunities, forming a network of independent companies. By utilising current information and communication technology it is possible to subjugate confines of time and distance so that virtual organisations may be formed in direct response to the marketplace.

2.3 Virtual Organisation Characteristics

In the next sections there will be a discussion of a virtual organisation's primary and secondary characteristics, where primary characteristics are inherent to all virtual organisations whilst secondary characteristic are acknowledged but not essential for the definition of a virtual organisation.

2.3.1 Primary Characteristics

The following are principal characteristics of a virtual organisation identified the published literature.

1. Core competencies**:** Core competencies of the partner organisation are the fundamental building blocks of virtual organisations. The combination of all core competencies leads to synergy and enables a flexible way of meeting customer demands. Partner enterprises can meet market demands by sharing skills where a single enterprise would be without the capacity to do so. Participants complement each other enabling a collaborative delivery of product or service. The number one advantage of being part of a virtual

organisation is the opportunity to embrace bigger projects in a more streamlined way than individual enterprises are able to (Christie and Levary, 1998).

2. Information Technology: Vital to a virtual organisation's survival is information technology. Being globally separate enterprises, products and information resources group together in a virtual organisation through ICT (Travica, 1998), particularly the internet, but also improved transportation and global communication helps synchronise the relationships whilst keeping communication costs down (Sieber and Griese, 1998; Mowshowitz, 1994; Byrne, 1993). All authors (Lucas, 1996; Travica, 1997) who research the virtual organisation pinpoint ICT as an essential prerequisite for a successful virtual organisation. Global communication through ICT continues to expand and offer greater opportunity for personal communication between enterprises with the development of video conferencing etc...
3. Customer based and mass customisation: The basis of a virtual organisation is customer focused, satisfying the precise demands of the customer. A VO responds to a specific product or service requirement and dissolves collaborations once the project is completed (Christie and Levary, 1998) leaving partners with economic and legal autonomy (Bultje and van Wijk, 1998).
4. One identity: A virtual organisation's identity to the customer should be recognised as singular. Partners contribute skills to form a network with a valued product as the end result (Balint and Kourouklis, 2000). A virtual organisation with invisible partners and one identity is referred to as a "hard virtual organisation". If the partners remain visible it is seen as a "soft virtual organisation" (Aken et al. 1998).
5. Interdependence: Interdependence in a virtual organisation assumes all partners share accountability. All partners are duty-bound to actively take responsibility for their specific role and the overall success of the enterprise (Goldman, 1994; Scholz, 2000).
6. Based on trust: One of the most important characteristics of a virtual organisation is the extremely high level of trust needed amongst partners (Christie and Levary, 1998). As described by (Handy, 1995) "Virtuality requires trust to make it work: technology on its own is not enough." To share

knowledge and core competencies simply though technological not physical contact makes trust between partners obligatory.

7. No hierarchy**:** As each partner within a virtual organisation offers specialist knowledge and leadership on a particular part of the product/service, there can be no hierarchy (Jagers et al., 1998). Equality of partners creates a virtual organisation without hierarchy (Byrne, 1993). This structure is described as 'egalitarian' by (Sieber and Griese; 1998).
8. Vague boundaries: Collaboration and synergy between customers, competitors and suppliers leads to altered boundaries (Bultje and Wijk, 1998). Visibility of where partners start and finish is not easy to understand in a virtual organisation and re-defines the boundaries of traditional organisations (Davidow and Malone, 1992).
9. Opportunity driven: Virtual organisations are a temporary collaboration of partner organisation prompted into life by a specific business opportunity that independent organisations cannot provide alone (Byrne, 1993). One of the most important characteristics of a virtual organisation is its ability to react promptly to particular customer demand. Enterprises come together temporarily to collate skills in order to meet that demand. The next business opportunity will see the virtual organisation change partners to tailor their core competencies to that particular product (Davidow and Malone 1992).
10. Dynamic structure: By nature, the virtual organisation is seen as a dynamic organisational structure in that the enterprises involved are constantly changing and reforming. A network of regularly varying participants allows flexibility and can change almost daily (Travica, 1998).

2.3.2 Secondary Characteristics

The following characteristics are acknowledged but not essential to define a virtual organisation.

1. Small sized partners: small companies and/or parts of large enterprises. Swift decision making and the ability to innovate and respond to opportunities immediately is often not a characteristic of large enterprises (Camarinha-Matos and Afsarmanesh, 2005). The core competencies of partners are usually

only a unit of a larger enterprise. Smaller sized partners lead to greater flexibility in responding to market demands.

2. Semi-stable relations: Dependence between partners is temporary. Relationships are much less formal with the virtual organisation's partners being able to continue to survive without the virtual organisation (Byrne, 1993; Aken et al., 1998).
3. Shared ownership: This characteristic is related to the fact that every independent partner has its own interests in the virtual organisation, and that parts of the virtual organisation can be owned by different partners (Bultje and van Wijk, 1998).
4. Shared Leadership: Partners control their own materials and finances but not the virtual organisations resources (Aken et al. 1998).
5. Shared loyalty: The creation of a 'culture' within a virtual organisation is important in promoting loyalty within the virtual organisation community (Burn and Ash, 2000). "People determine the success of a virtual organisation" (Sieber and Griese, 1998).
6. Dependent on innovation: It has already been stated that a virtual organisation is often formed in response to market opportunities, the essential ingredient being responsiveness to this opportunity. According to Chesbrough and Teece (1996) the best way to react to a market opportunity is with products and services that are innovative, and innovative not simply from a technical point of view but, for instance, innovative in terms of the design of an organisation.
7. Geographical dispersement**:** This is defined as a company being "geographically dispersed if the buildings are separated" (Bultje and van Wijk, 1998). The use of ICT enables partners to communicate and work together despite time and distance constraints. Technology is such that it can create a feeling of teamwork and connectivity between partners on opposite sides of the world.
8. Lifespan of co-operation: temporary vs. permanent: Generally the lifespan of a virtual organisation is considered to be that of a temporary network of independent companies (Goldman et al., 1995; Byrne, 1993; Travica, 1997; Fuehrer and Ashkanasy, 1998; Handy, 1995). Aken et al. (1998) introduce the concept of "Project" for a temporary organisation, and "Program" for the long lasting organisation. As an example, a virtual organisation can be disbanded in

the event of project completion, but can also have an undetermined duration in the case of the organisation remaining functional for as long as customer demand exists and/or the participants find their collaboration to be beneficial (Jagers et al., 1998).

9. Balance of power: equality of partners vs. core–partners: The virtual organisation's functional process creates a culture defined by sharing of information and skills and lacking hierarchy. Partners are reliant upon each other for the end product to succeed thus replacing the traditional control based business culture. Each partner offers leadership in their particular skill. Sometimes the partner awarded the business initially will function as a low profile project leader bringing the network of partners together for the virtual organisation. A distinction made by (Aken et al., 1998) is that a 'core-partner' actually leads the virtual organisation.

2.4 Virtual Organisation Life Cycle

Figure (2-1) represents a minimal life cycle model including creation, operation, evolution, and dissolution stages (Spinosa et al. 1998; Camarinha-Matos and Afsarmanesh, 1999).

Figure 2-1 The Life Cycle of a Virtual Organisation

A well-accepted life cycle model for virtual organisations includes four stages (Camarinha-Matos and Afsarmanesh, 1999, Spinosa et al., 1998; Afsarmanesh and Camarinha-Matos, 2005):

1. Creation: The first stage is the creation of the virtual organisation with partners being sourced, the sharing of level agreements, contracts being negotiated, definition of rights and join/leave procedures etc… being formulated.
2. Operation: This is the business process phase when the virtual organisation is producing an end product. Necessary to this phase are secure data exchange mechanisms, management of orders, task management etc…
3. Evolution or Re-configuration: Modifications might be necessary during the operation of a virtual organisation when there is the need to add and/or replace a partner. This might happen due to the occurrence of some unexpected event, such as (temporary) overloaded capacity of a partner, lack of adequate human resources, etc…
4. Dissolution: This is the last phase. There are two possibilities for dissolving a virtual organisation: a successful dissolution (when the virtual organisation finishes its business having achieved all its goals) or an unsuccessful dissolution (when some problem occurs during the operation phase which, for some reason, cannot be solved). In the last case the common goal is not achieved and the partners decide not to go ahead with the collaboration.

Strader et al. (1998) define an alternative life cycle for a VO, which includes its formation, operation and winding up as shown in figure (2-2).

Figure 2-2 Virtual Organisation Life Cycle Model (Strader et at., 1998)

1. The identification phase involves identifying where opportunities exist for a VO and then evaluating the available opportunities before moving to selection, all of which is a sequential process. The opportunities that have been identified themselves act as the input for the processes of evaluation and selection. This phase of the process ends once identification has been made of the best market opportunity which is potentially chosen and, subsequent to this stage, the particular selection provides the input for the formation phase.
2. In the formation stage major decisions have to be made which will include the identification of appropriate partner/s, leading to evaluation of these and a final selection, as a result of which the partnership will be formed. Once again the process of decision making is sequential. Therefore, the input at this stage derives from the process of partner identification and the output is a list of potential partners. This list of potential partners then becomes the input necessary to move on to the process of partner appraisal and selection. The final result of this process is a number of partners that are selected to work together in a VO in order to take up a particular market opportunity. This process where partners are brought together is, in effect, the formation of the firms that have been selected into a virtual organisation which, once it has been formed, can begin to operate.
3. In general within this operation phase there are five different, important decision making processes which include design, marketing, financial management, manufacturing and distribution. However, unlike the decision making processes in the first two phases of the cycle, in this phase of the operation the decision making processes are not sequential with each one of the processes arriving at a decision being reliant on input and output from the other decision processes in a way that is ongoing, which means that this phase presents the greatest difficulties in terms of its management. This final process needs to utilise all the information that has been gleaned during the first two processes relating to the market opportunity as well as the association between the external partners. The information that is gathered from all these processes provides a summary of all the activities and transactions that have occurred during the operation of the virtual organisation. Once the market opportunity comes to an end, the operation phase also ends and the termination phase is able to commence.

4. The most important decisions that have to be taken in the termination phase relate to the ending of the operation and the dispersal of the assets and, as in the first two phases, these processes are sequential. The input into the termination session includes any current operational information, which is likely to include inventory levels and uncompleted orders. When all this information has been acquired the dispersal of assets can begin. This process requires the input of the necessary accounting and legal information to terminate the contracts and disperse any assets of the partnership between the partners. The completion of this process marks the point at which the various enterprises that have been involved become free to consider further opportunities and form new partnerships since the previous virtual organisation can be considered to be defunct. At this point the organisation's life cycle comes to an end.

The SYNERGY project (2009) has identified four distinct stages within the lifecycle of a typical VO, which includes pre-creation, creation, operation and termination as shown in figure (2-3).

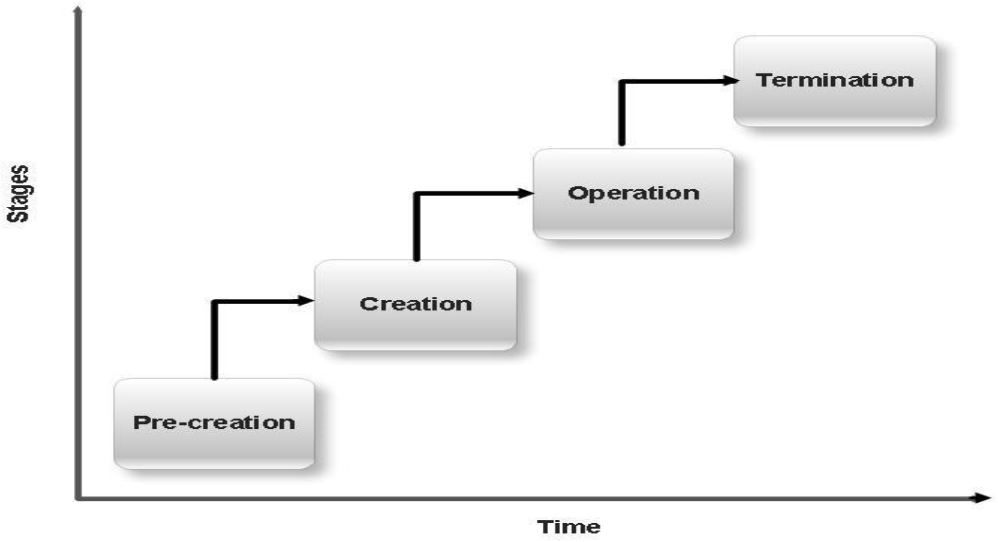

Figure 2- 3 Typical lifecycle of VO within the context of SYNERGY project

The different activities that may take place in these stages are briefly explained (SYNERGY D3.1, 2009):

1. Pre-creation stage. This is the stage where the prospective SMEs may form one or more collaboration pools with the objective of gaining themselves new collaborative business opportunities. In this stage potentially collaborative companies need to be made aware of potential business opportunities by some mechanism. Interested companies may start negotiations with prospective partners having complementary skills or competencies for the possible formation of a virtual organisation in order to compete for a particular business opportunity.
2. Creation stage. In this stage, stronger partnerships are made between companies through the formation or creation of a virtual organisation in response to a new business opportunity. During the negotiations between the partner companies, it is likely that a leader or coordinator orchestrates the subsequent successful rounds of negotiations so that a new VO is formed. Then the VO moves into the operational stage to exploit the particular business opportunity, which is often termed as a project.
3. Operation stage. The main objective of the VO during the operation stage is to deliver items in time as promised to the customer. As the partners within the VO will be working together they will need to gain and share knowledge about the product or service they want to deliver to the customer. During the project operation, unexpected problems may occur for example varieties of conflicts of interest, partners unwilling to continue in the project, falling behind the schedule etc. These problems need to be resolved through successful negotiations amongst the partners of the VO to make the project a success and maintain the business reputations of the connected partners.
4. Termination stage. At some point the VO will have completed the project that it was set up to carry out and the deliverables will have been passed on to the customer. The purpose of forming the VO has therefore been completed and the VO should therefore terminate. However, each individual partner still exists. They are likely to also still be part of the collaboration pool and be available for future VO collaborations.

2.5 Comparison of Virtual Organisations, Supply Chains, and Extended Enterprises

There are three fundamental features of the virtual organisation concept that differentiate between a virtual organisation and a traditional organisation. These three

features have consequences that 'shift' the paradigm of the virtual organisation (Putnik et al., 2005).

1. Dynamics of network configuration.
2. Virtuality.
3. External entities (virtual enterprise structures) enabling/supporting the integration of the virtual organisation.

A Supply Chain is "a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the feed forward flow of materials and feedback flow of information" (Stevens, 1989).

Models of virtual organisations are similar to the way supply chains are managed, partners being integrated and running along side one another. Pires et al. (2001) discussed how a co-operative enterprise working as a virtual organisation automatically gains the same features as a supply chain structure.

The majority of individual enterprises do not have the capability of controlling an end product from start to finish. Businesses have begun to realise that an integrated supply chain can afford them competitive advantages (Ballou, 1999). A supply chain illustrates a network of singular functions, from initial material sourcing to final distribution, that transform into a finished product (Lee and Billington, 1993).

The objective of supply chain management is to reduce costs and add value to the end product by capitalising on the synergy between all the separate participants of the demand chain. Supply chain management is able to limit the number of transactions, transport costs and inventory costs whilst creating a product with added value that is tailored to the customers' needs. Customers are provided with a faster service led by the development of distinct competencies and this in turn puts the enterprise in a competitive position (Collins et al., 1997).

Supply chain management objectives are based on how the enterprise relates to customers and suppliers. This should act as a guideline to other members of the supply chain showing that strategic collaboration can only enhance the value of the chain as a whole and not as individual enterprises. This tactical use of collaboration has altered the way many businesses manage their manufacturing (Pires, 1998).

2.5.1 Supply Chain and Virtual Organisation Comparison

To compare and analyse differences between supply chains and virtual organisations (Pires et al., 2001) the following aspects need to be examined:

1. Main purpose of a partnership: A virtual organisation's main objective is to capitalise and utilise particular business opportunities using core competencies of different enterprises, whilst the supply chain main aim is to reduce costs whilst maintaining competitiveness and value to the customer.
2. Organisational Structure: The supply chain's stability is due to a fairly inflexible structure of established relationships that are long term and mutually dependent. This interdependence across the value chain doesn't allow for flexible variations in vendors or customers, whereas a virtual organisation affords the members more freedom in creating and dissolving alliances in accordance with phases of a process or simply in response to the customers' needs.
3. Co-ordination: A virtual organisation may have a nominal leader but all partners are expected to take an active role and responsibility for co-ordination and planning. In contrast, a supply chain usually has a designated head 'company' or leader that is responsible for managing and co-ordinating all components of the supply chain.
4. Duration: A supply chain relies upon established relationships defined within contracts that are generally long standing and for a specific period. Contrastingly, a virtual organisation can be brought to life, fulfil the customers' need and be dissolved in quick response to market demand.
5. Participation: Enterprises are able to involve themselves in many networks of virtual organisations whilst still maintaining autonomy. At the same time an enterprise may simultaneously collaborate with several supply chains but with a level of exclusivity in the relationship.
6. Suitability of the concept of product life cycle: A product's life cycle is conception, growth, maturity then decline. The reason a virtual organisation is so effective in the initial phase of conception is that their strength is in gathering the diverse competencies required to utilise the new opportunity. In comparison the structure of a supply chain is such that its established partner

relationships means its strengths lie in the remaining phases of the product life cycle, i.e. maintenance and increased competitiveness.

7. Speed of industrial innovation: In terms of product development the virtual organisation provides huge flexibility. In any sector survival depends on innovation and utilising a VO can be the most appropriate form of co-operation to ensure a competitive place within the business market. Contrastingly, a supply chain produces a much more stable and long term product that does not rely upon quick change innovation for it to survive.
8. Market Qualifiers competitive criteria: Conceptually virtual organisations and supply chains differ when looking at market winners/qualifiers, agile supply/lean supply (Christopher and Towill, 2000). Lean supply criteria are quality, total lead time and service level allowing the company a competitive place within a certain market sector. This is the aim of the supply chain, to create a value stream that has eliminated all wasted costs and forms a productive chain. Agile supply criteria differ in that their prerequisites in a competitive market are quality, total costs and lead time. This concept is in line with how a virtual organisation is defined. Agile supply relies heavily upon market knowledge to exploit opportunities with a quick turnaround.
9. Market Winners Competitive Criteria: Christopher and Towill (2000) argue that the lean supply paradigm and the supply chain model is most powerful when the winning criterion is cost; however, when service and customer value enhancement are prime requirements for market winning then the likelihood is that agility (or the virtual organisation) will become the critical dimension.
10. Demand Characteristics: The nature of a virtual organisation is that it has the ability to respond immediately to customer and market demands. Contrastingly the supply chain nature is more cautious and generally relies upon sales forecasts based on previous figures (Christopher and Towill, 2000).

2.5.2 Extended Enterprises

The extended enterprise is an expression of the market driven requirement to embrace external resources in the enterprise without owning them. Core business focus is the route to excellence but product/service delivery requires the amalgam of multiple world class capabilities. Changing markets require a fluctuating mix of resources. The

extended enterprise, which can be likened to the ultimate in customisable, reconfigurable manufacturing resource, is the goal.

The operation of the extended enterprise requires take up of communications and database technologies, which are near to the current state of the art. However, the main challenge is organisational rather than technological (IMS, 2003). The extended enterprise is responsible for the whole product life cycle, from material procurement to component production and manufacturing, to final assembly to distribution and customer service and, in an increasing number of cases, recycling of end-of-life products.

2.5.3 Extended and Virtual Organisation; Similarities and Differences

Enterprise partnerships are a collaborative alliance of independent enterprises including customers, suppliers, service providers etc... As defined by Mariotti (1996), they are a relationship between companies and people who share common goals, strive to achieve them together and do so in the spirit of co-operation, collaboration and fairness. Extended enterprises focus on creating longer term relationships throughout the value chain, whereas virtual organisations target a niche market using shorter term relationships.

It is helpful to compare both approaches to enable us to clearly see the differences and similarities.

Zhang (1998), Browne and Zhang (1999) consider that although both manufacturing systems share many characteristics there are differences. The extended enterprise and the virtual organisation can be seen as two complementary manufacturing strategies. Their similarity lies in the fact that they both pursue enterprise partnerships in order to achieve business success in a very competitive environment. The major difference lies in the dynamic nature of one versus the relative stability of the other. The extended enterprise requires organisational stability and enduring relationships across the value chain. On the other hand the virtual organisation depends on high technology and advanced information systems in order to successfully integrate the business partners for a short time.

2.6 Virtual Organisation Advantages

The virtual organisation is able to provide access across a variety of specialised resources and is able to show large corporate buyers a unified entity while at the same time individual members of the voluntary organisation are able to remain independent and develop their specialised skills. At the inception of a project a VO is able to make use of the advantages conferred by flexibility, adaptability and speed.

Several authors have discussed the benefits and advantages that virtual organisations may have, such as Wu et al. (2002) who showed that a virtual manufacturing model manifested the advantages of reduced cost of production, improved product quality and shortened lead-time. This is in accordance with the objectives in forming a virtual organisation network, these being to satisfy customer demand by drawing on the greatest competency of each member while at the same time decreasing production costs.

It has been suggested by Skyrme (1996) that the setting up of a virtual organisation can confer the following benefits:

- Access to a wide range of specialised resources.
- The presentation of a unified face to large corporate buyers.
- Individual members are able to retain their independence and continue to develop their core competences.
- An enterprise can be reshaped and its members changed according to the demands of the project or task in hand.
- The need to worry about “divorce settlements” as they exist in formal joint ventures, is removed.

Camarinha-Matos (2002) suggests that when organisations that are intrinsically dynamic come together in order to meet the needs and opportunities presented by the market and are able to remain in operation for as long as the opportunities remain, then a number of benefits ensue, among which are the following:

- Agility: This is the capacity to recognise and then deal with whatever unexpected changes may arise in the environment so that it is possible to more successfully respond to opportunities as well as achieving decreased time to market together

with higher quality for less investment. A VO is able to meet the need to bring together the most appropriate set of skills for any particular VO together with the resources that stem from various specific individual organisations and it is also able, should it become necessary, to reorganise itself either through the addition or the expulsion of members or else by actively redistributing the tasks, or the roles of its members.

- Complementary roles: An enterprise will aim to have complementary aspects, that is to create synergies, in order to seize creative business opportunities and develop new markets.
- Achieving dimension: So far as SMEs are concerned, becoming part of a partnership involving others means that they are able to reach a critical mass and present themselves to the market with a greater 'visible' size.
- Competitiveness: Cost effectiveness can be achieved where subtasks are appropriately apportioned between those organisations cooperating together.
- Resource optimisation: This occurs when smaller organisations are able to share an infrastructure as well as knowledge and business risks.
- Innovation: There is increased opportunity for the exchange and evaluation of ideas within a network and this is likely to lead to increased innovation.

Grimshaw and Kwok (1998) have identified the following benefits based on a case study of a voluntary organisation:

- Increased competitive capabilities.
- Flexibility.
- Greater responsiveness to market (customers).
- Improved customer service.
- Cost benefits.
- Improved communication and internal control.

It can be seen that many of the benefits accruing to virtual organisations stem from their capacity to modularise, a modular organisation being one in which coordination is the norm so that processes appertaining to organisation can be undertaken within a loosely-coupled structure, with each organisational unit that takes part able to function concurrently but also independently (Sanchez and Mahoney, 1995; Johnson and Scholes, 1999). According to Sanchez and Mahoney (1995) an organisational structure that is modular is better able to rapidly bring together the resources and

capabilities of a number of organisations in order to make product development 'resources chains'. These are able to provide a flexible response, that is broad, rapid and low cost, to opportunities for new markets and technology by having available products that are either new or modified. A virtual organisation includes many of the principles that underlie modular organisations.

The advantages listed above mean that the a virtual organisation provides a compelling choice for many enterprises, particular in the light of the continuing improvements in information sharing and the coordination technologies that these organisations need in order to function.

2.7 Reasons for Adopting the Virtual Organisation Structure

Goldman et al. (1995) maintain that the advantages offered by virtual organisations are substantially greater than any disadvantages, stating that the virtual organisation "is dramatically better than business as usual for a network of enterprises sharing a business opportunity" and they offer six strategic reasons why the VO model should be adopted:

1. In the event of a VO being set up in order to bring a new product to market, the resources put into the infrastructure, together with R&D, costs and risks would be shared.
2. Any particular enterprise becoming part of the VO would benefit from the opportunities that would be provided by allying its own main internal competency with those of the other companies involved.
3. The notion of the time involved would be reduced because the knowledge and skill of various enterprises would be brought together so that the boundaries of the enterprises operating simultaneously would be expanded.
4. The size and scale of operations would be reduced, in the first place through the economy of scale that follows where one company is being worked for rather than a number of separate entities, and secondly in relation to the customers.
5. By becoming part of a VO an enterprise would gain access to new markets as a result of the partnerships which would mean that the loyalty bases of the customers of a particular enterprise would be shared by virtue of the

value that would be added to the new product that the partnership developed.

6. As a result of an enterprise being part of a VO there would be an increase in the speed with which an enterprise moved from selling products to selling solutions.

2.8 Risks and Limitations of Virtual Organisations

Along with their numerous advantages virtual organisations together with the virtual integration of supply chains also pose several challenges, including risks such as lack of trust, lack of top management commitment, insufficient information sharing, inadequate collaboration agreements, ontology differences, risk from heterogeneity, structure and design risks, loss of communication, culture differences, difficulties arising from geographic distribution, knowledge about risks, bidding for several virtual organisations at the same time and wrong partner/s selection.

All of these risk sources will be discussed in Chapter (5). They all require serious attention in the formation and operation of the virtual organisation and therefore have been examined carefully to address objective 3 of this research.

Chapter 3 Risk literature review

3.1 Introduction

In this chapter the literature dealing with the risks to virtual organisations, beginning with risks in the supply chain, will be discussed. Risk propagation impact will be addressed before examining the most universally used definitions of risk, the relation between risk and uncertainty and also the differentiation between objective and subjective risk as it occurs in the literature. In the second part of the chapter there will be a discussion of risk management approaches, and the previous models for the identification of risk in supply networks. The essential elements of the risk management process including identification and assessment, which are the main core of this research, are then considered.

3.2 Risk in Networking

There are many benefits associated with networking, but it cannot be considered as being risk free. Both Small and Medium sized enterprises (SMEs) in particular have been at the forefront of significant changes when functioning as a partner within a virtual organisation. These enterprises have been compelled to adjust swiftly and with a great deal of flexibility, due to the pressure imposed by the astonishing speed at which technology has been developing, and by the mounting international competition. In assessing risks within the framework of a VO, it is vitally important that enterprises recognise all types of risks, not only direct risks to their operations but also the risks to all other entities as well as those risks caused by the linkages between them (Jüttner, 2005).

To further enhance the understanding of virtual organisation risk, it is worth exploring the existing similarities between this and supply chain risk, and compare risks in relation to virtual organisation, supply chain and joint venture. This comparison could potentially yield practical proposals resulting from research in this area, and fill in the gap in the study of risk in VOs (Chen and Chen, 2006).

Hallikas et al. (2004) argue that although collaboration can be useful as a strategy to manage and to minimise risks, it tends to bring in new risk factors.

Harland et al. (2003) assert that the difficulty is caused by a variety of factors such as globalisation, mounting product/service complexities, subcontracting, e-business and demanding customers' needs. These factors have led enterprises to depend more and more on their outside resources but these come with risks. In turn, corporate risk management, in terms of its function, has been modified to provide a counter impact to external sources of risk.

In relation to supply networks, the basis of vulnerability comprises various risks. Johnson (2001) suggests that there are two types of risks in a supply chain; the first type is concerned with product demand (seasonality, volatility), and the second with product supply (capacity, limitations, supply disruptions). Chopra and Sodhi (2004) propose other risk categories such as disruptions, delays, systems, forecasts, intellectual property, procurement, receivables, inventories and capacity, and argue that each one could have a number of variations vis-à-vis source and form of impact.

Risks and benefits in joint ventures are, as a rule, shared through combined ownership and with official agreement in relation to various aspects, such as obligation contracting, profit distribution and the provision of incentive systems for the collaboration parties concerned (Harland et al., 2003). Formality is paramount in collaborations as its lack may lead to less understandable risk and disrupt stability and benefit sharing.

Risk management is by no means an easy task due to the nature of its dynamics and the complexity of supply networks. The moment enterprises in the supply networks begin to develop an over reliance on each other, they become highly likely to be affected by the risks and weaknesses of one another.

Zsidisin et al. (2000) draw attention to supply risks linked to design, cost, quality, availability, manufacturability, supply, legal and environment, and health and safety.

In their assessment of critical risk factors, Sutton et al. (2008) point out that a complete organisation's enterprise risk may be distorted by the ambitious extended enterprise systems in relation to B2B e-commerce. Furthermore, in an attempt to unravel how different factors affect each other and contribute to the overall risk, they investigate the interrelationships between varieties of risk factors in B2B e-commerce.

It appears that the risks connected to collaboration are not purely dependent on a single enterprise's aims and objectives, despite the desire of some parties in these relationships to assume control and also the duty of completely managing the supplier network. The mounting distribution of responsibilities and the very nature of these relationships need to be scrutinised (Hallikas, 2002).

3.3 Risk Propagation Impact

Zsidisin (2000; 2004) defines risk in the circumstance of the supply chain as being the possible incidence of an event related to inbound supply in which the aftermath points to the failure of purchasing organisations to satisfy customer demand.

Chang and Makatsoris (2001) claim that risk propagation can influence whole areas of the supply chain where the overall business losses could be massive. It causes cycles of excessive inventory and severe backlogs, poor product forecast, unbalanced capacities, poor customer service, uncertain production plans, and high backlog costs, or sometimes even lost sales where numerous gains are expected from managing the risk such as improvement in the throughput, cycle time reduction, inventory cost reductions, optimised transportation, increased order fill rate and increased customer responsiveness, all aspects of the supply chain where the overall business losses are potentially massive.

Weisenfeld et al. (2001) and Gunasekaran (1999) see the propagation of risk as influencing partners and the entire virtual organisation, and identify four major elements where the effect is evident: time, cost, quality and complete failure.

3.4 Risk Definitions

Definitions of risk are generally varied; however, the Royal Society (1992) has scientifically defined it as "The probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge. As a probability in the sense of statistical theory, risk obeys all the formal laws of combining probabilities".

Numerous debates revolving around risk outline it in the light of conventional decision theory as in the examples of March and Shapira (1987) and Borge (2001). It

is possible to suggest that risk is viewed as the potential good aspect as well as the downside of a solitary lucid and scientific (financial) decision.

For March and Shapira (1987), risk is the "variation in the distribution of possible outcomes, their likelihoods, and their subjective values".

Conversely, it is regarded as a possibility of injury, damage or loss in most dictionaries and in the insurance domain (Webster, 1983). Here, risk appears to harmonise with the common perception held by people, and is chiefly associated with negative outcomes.

On this note, March and Shapira (1987) conducted an empirical study with the aim of evaluating managers' perception of risk and the way they respond to it. The results astonishingly revealed that most of them lean towards overvaluing the possible negative aspects of risk. This is an opinion widely shared between academics in the domain of supply chain management and supply management.

Jüttner et al. (2003), describe supply chain risk as a "variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective value".

Other definitions of risk have emerged over the years. For example Mitchell (1995, 1999) argues that risk is generally regarded as an indication of variation in the allocation of potential results, their likelihoods and their subjective values. Mathematically, he proposes the following formula to illustrate the definition above:

$$\boldsymbol{Risk\ n\ =\ P\ (loss\ n)\ x\ L\ (loss\ n)}$$

Where n is the event, P is the probability and L is the significance.

After having reviewed a number of definitions, Harland et al. (2003) have come to a general definition of risk as the chance of danger, damage, loss, injury or any unwanted consequences. Likewise, Norrman and Jansson (2004) view risk from a quantitative angle as the chance of a distinct hazardous happening.

Risk is, according to Spekman and Davis (2004), the prospect of inconstancy in an anticipated end-product. Sinha et al. (2004) believe risk involves the combination of insecurity and the impact of an occurrence; a view that is echoed by the likes of Avena et al. (2007). Finally, Yang and Qiu (2005) suggest that risk is a subjective

insight that relies on the individual's partiality. They continue to state that risk is relatively a reference to the possibility of a probabilistic occurrence taking place.

3.5 Risk and Uncertainty

Although risk and uncertainty are closely connected, they are not the same. Knight (1921) clearly distinguishes the two by stating that risk can be quantified allowing estimates of the likelihood of the outcome, whereas uncertainty cannot be measured; thus the likelihood of the possible outcomes remains unknown. Conversely, Adams (1995) reveals that "virtually all the formal treatments of risk and uncertainty in game theory, operations research, economics and management science require that the odds be known, that numbers be attachable to the probabilities and magnitudes of possible outcomes". In this sense, risk management aims to identify, measure, manage and, whenever required, eradicate poorly defined risks. There seems to be a reversion in the understanding of the essence of risk outlined in more up-to-date development.

Since risk tends to be subjective in meaning, it remains inconclusive in its definition. Risk is regarded as the "variation in the distribution of possible outcomes, their likelihood, and their subjective values" (March and Shapira, 1987). It is noticeable that the term "risk" is mostly used alongside the terms "uncertainty" and "vulnerability".

Chapman et al. (2002) argue that vulnerability is the outcome of exposure to severe upheaval instigated by risks. On the other hand, uncertainty occurs when a factor "reduces the predictability of corporate performance, that is, increases risk" (Miller, 1992). It is, therefore, safe to conclude that uncertainty leads to risk which in turn results in vulnerability, as illustrated in the figure (3-1) below:

Figure 3-1 Risk-related Terminology (Miller, 1992).

Hutchins and Gould (2004) emphasise the importance of risk management in the process of interacting with the presence of uncertainties by way of "controlling variability from an objective, target specification or standard".

The fact remains that uncertainty creates complications in most business scenarios, and is a major contributor to risk and vulnerability in the majority of supply chains. On the other side of the spectrum, it can be argued that all notions of risks come with the implication that there has to be uncertainty surrounding the potential outcomes, and if the probability of these outcomes is known the risk is non-existent (Yates and Stone, 1992).

Similarly, Slack and Lewis (2001) embrace both views in describing uncertainty as a crucial constituent of risk, but argue that managers can quantify as well as alter their exposure to risk by nurturing mitigation, and preventative and recovery strategies. While these cannot guarantee the eradication of uncertainty, they assist managers in the reduction of risks that may be caused by uncertainty.

It is evident that the debate concerning risk and uncertainty is crucial and such debate reveals a number of discrepancies in the views concerning risk. However, this research takes into consideration that whilst uncertainty may not be measurable, risk is both measurable and manageable.

3.6 Objective and Subjective Risk

In a report presented by the Royal Society in relation to the issue of risk, a clear distinction is drawn between "objective risks" and "perceived risk". The former is defined within the scientific boundary as a quantitative tool while the latter is identified by the experts of the Royal Society as "the probability that a particular adverse event occurs during a stated period of time, or results from a particular form of a particular challenge. As probability in the sense of statistical theory, risk obeys all formal laws of combining probabilities" (Royal Society, 1983). The combination of this 'objective' position and the definition of 'detriment' as being 'the numerical measure of harm or loss associated with an adverse event' provided by the Royal Society, mirrors the complex gauge of risk which is commonly faced in the sphere of risk and safety literature (Adams, 1995).

With reference to the connection between objective and subjective risk, Mitchell (1999) suggests that the former has a place only in theory as its measure is hard to achieve, which allows the subjective measure of risk to be easily in the most prominent position.

In differentiating between objective risk and perceived risk, Das and Teng (1996) argue that objective risk is founded on the outcomes of options and their probabilities. Moreover, it can be calculated from an objective angle rooted in known potential outcomes and their probabilities, as in the example of card games. In contrast, perceived or subjective risk is determined by the estimates of the decision makers of objective risk (Dowling 1986; Fischhoff, 1985). This in turn, may lead to different estimates being provided by decision makers about the degree of risk in any situation.

3.6.1 Is Risk Objective or Subjective?

In the light of the debate over whether risk is objective or subjective and in the views of authors such as (Frosdick, 1997; Moore, 1983; Spira and Page, 2002; Yates and Stone, 1992), Lupton (1999) it has been noted that these views of risk are of two types; the technico-scientific and the social constructionist. The former regards risk as objective and measurable, whereas the latter views it as subjective and shaped by the social, political, and historical opinions of the parties involved.

Yates and Stone (1992) are in favour of the latter view supporting their claim by suggesting that risk is subjective as it illustrates a form of communication between the choice and the ensuing risk. They go on to state that any potential loss including its implications and the predicted chance of it happening are solely reserved for the individual concerned. For instance, the outcome of risk can be conceived as being positive by some and negative by others. Hence risk is not an objective characteristic of decision choice. Similarly, the Royal Society (1992) asserts that a given risk may have different meanings to different individuals in different situations, and maintains that risk is socially formed. Nevertheless, it admits that to physical scientists and engineers, risk is objective, measurable and manageable.

Evidence suggests that the debate between those who regard risk as objective and their counterparts, who view it as subjective, will probably never be resolved. Therefore, it is not intended, in this study, to reach a resolution in this area. However,

it is paramount to acknowledge that this debate offers, at the very least, an insight into how risk is viewed and managed. It is also vital to acknowledge that a significant number of those concerned with the study of supply chains are unaware of the ongoing debate over its nature. Some use a particular terminology such as "perception" and "perceived", such as (Cousins et al., 2004; Kraljic, 1983; Williamson, 1979) to sway the argument towards the side of subjectivity, and others use the term "probability" (Harland et al., 2003) to point in the direction of objectivity. What is paradoxical is that the question of whether risk is an objective or subjective construct is apparently not acknowledged in the literature relating to the supply chain. Besides, whether it is considered to be subjective or objective, the fundamental question for organisations is how risk can be managed.

A similar view has been adopted by the Royal Society suggesting that the process of risk management exists to make and enforce decisions related to risks anchored in risk estimation and evaluation. The objective, for the Royal Society, is a matter of lessening the impact of risks by methods for shrinking the probability of their incidence and /or by evading their consequences.

3.7 Risk Management Approaches

The Royal society (1992) defines risk management as a sequence of steps and measures created by organisations to counter any form of risk exposure. This process normally incorporates identification of risk and its measurement as well as control and observation.

The primary aim of risk management, according to Norrman and Jansson (2004), is to comprehend the implications of risks and to reduce their impact by paying attention to elements such as probability and impact. It is also important to note that the phases in relation to the process of risk management may appear to be variable in terms of labeling as in, risk identification, analysis or (estimate), risk assessment or (evaluation), and different strategies for risk management. However, 'labels differ among authors,' but 'the steps are similar' (Norrman and Jansson, 2004).

A number of approaches have been developed in risk management and Supply Chain Management (SCM) to tackle the roots of risk in supply chains.

Norrman and Jansson (2004) explain that Ericsson's feedback SCRM approach consists of a set of phases that are simple to understand, beginning with incorporated risk, identification, assessment, remedy and observation and including occurrence management and backup planning in order to diminish risk exposure in supply chains.

3.8 Risk Models for Supply Networks

In relation to risk for supply networks, Harland et al. (2003), present a model, as illustrated in the figure (3-2) below, which adheres to the conventions of a systematic discipline starting with mapping the supply network and ending with implementing network risk strategies.

Figure 3-2 Supply Network Risk Model (Harland et al., 2003).

The steps in the figure clarify the procedure for the model as follows:

1. Map supply network: This may involve identifying who possesses what, and what principal measures are presently put in place as for example transparency in role and responsibility within the network. It is also the start of the risk tool model.
2. Identify risk and its current location**:** This is step two of the procedure of the tool during which the sources of the risk are located.

3. Assess risks: This is step three and involves scrutinising the selected risks to determine the likelihood of their incidence, exposure in the network, and possible causes.
4. Manage risk: This is the phase where the management of risks is a primary target, and where risks begin to be analysed within the network and their associated damages are calculated.
5. Form collaborative supply network risk strategy**:** Here the possibility of selecting more appropriate options for treatment of the risks being examined arises.
6. Implement supply chain risk strategy: This is the final stage where the real option strategy is implemented followed by a remapping of the network

Zsidisin et al. (2004) propose a process which incorporates the following elements; identification, manager appointment, initiation of score card, criteria review, data collection, assignment of risk scores, impact analysis, document analysis and action, monitoring, and decision to end assessment. The process itself is known as the 'Ten-step SCRM' and consists of eight risk factors.

It appears that the process of risk management applied to the network risk within a virtual organisation and the steps taken are representative of risk management that adheres to risk identification, risk assessment, identification and implementation of risk reduction and risk monitoring.

Pfohl and Buse (2000) are of the view that it is strategic networks and virtual organisations that should be at centre stage. In regard to virtual organisations, they suggest they symbolise dynamic networks, and are not based on a hierarchical system. This allows an enterprise to function as a liaison officer in a network including customers, suppliers, services, providers and other specialised services. Conversely, strategic networks tend to be firmer in their nature. There is a division of roles in the network which can make coordination challenging in the sense that responsibilities are to be undertaken by all parties including the first tier supplier and the multi-tier suppliers. The network can also be structurally complex due to the nature of the logistics and service providers linking the first buyer to the first tier supplier.

Supply chain risk management according to Norrman and Lindroth (2004) is the collaboration of partners in applying the risk management process in a supply chain and deploying the appropriate means to tackle 'risks and uncertainties caused by or impacting on logistics related activities or resources'. This description of risk management in a supply chain can fit in with the needs of a single enterprise in the chain when dealing with its risk management concerns.

Blackhurst et al. (2004) acknowledge that naturally the activity of every enterprise carries a commercial risk to a certain extent, and taking part in a network enterprise brings with it other risks in relation to collaboration. These risks are evident, for example, in the failure of a particular partner, and may lead to accruing cost to replace a service or a partner. There are also risks associated with loss or exploitation of confidential commercial data.

As well as this, the inadequate understanding of technology and uncertainty over the collaboration and commercial abilities of other partners, make risk assessment, that is meant to be effective in decision making, more complex and more of an obstacle standing in the way of the need to administer risks presented by various interacting sources.

Both the entwined relationships between risks and their possible impact on the network or the individual enterprise, develop within the life span of a network enterprise (Lin and Patterson, 2007).

On the same note, in their view of risk management and its strategies in worldwide supply chains, Manuj and Mentzer (2008), assert that global supply chains tend to be less safe than home ones. This is the result of the vast number of connections within an extensive network of establishments. These connections are highly likely to cause a number of negative outcomes such as insolvency, distraction, collapse, global economic and political instability and catastrophes. Therefore, risks levels multiply and their management becomes a daunting task.

In tackling risk management problems, Gaonkar and Viswanadham (2007) propose a model which categorises these problems and outlines ways to seek solutions. They suggest three levels to deal with risk management troubles; strategic, operational and tactical. They also claim that unanticipated incidents in the supply chains can be dealt with via two obvious approaches; the first one aims at devising chains integrated with

risk tolerance and the second is concerned with limiting the damage in the event of unexpected incident.

In describing SCRM as a managerial task, Jüttner et al. (2003) suggests that it is "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". This description shares common features with the one put forward by Lindroth and Norrman (2001) with the exception that the latter adopts a narrow outlook by viewing SCRM as being concerned with 'risks caused by, or impacting on, logistics-related activities or resources'.

3.8.1 Risk Management Process

It is essential that risk management plays a fundamental part in the management and planning of any given organisation. Moreover, for a risk management program to be effective, it has to be a progressive course of assessment, intervention and contingency planning (McGrew and Bilotta, 2000).

Bandyopadhyay et al. (1999) point out four principal constituents of risk management:

1. Risk identification: this involves identifying and measuring the exposures which could jeopardise a company's assets and prosperity.
2. Risk assessment: this entails identifying and evaluating risks imposed on a company and its assets so as to opt for suitable and reasonable defensive measures.
3. Decision and implementation of risk management actions: this involves risk deduction, transfer and response, decreasing or shifting the weight of financial loss, particularly in the case of a crisis, to ensure that a company is able to proceed with its operations without distorting its fiscal steadiness.
4. Risk monitoring: this refers to the continuous assessment of present and possible future exposure.

In general, the risk management process within a network setting consists of the same steps, and every enterprise functions at its own risk as well as bearing the responsibility of managing its own risks. Also, the interdependent nature of

enterprises in the network can be helpful in the sense that the risk management process is shared and collaborative strategies are developed to control risks.

Smallman (1996) argues that successful risk management does not have to be excessively formal or be an ordered process, but it ought to be commonsensical. However, most observers prefer a stricter structured approach when it comes to managing risks (Frosdick, 1997; Royal Society, 1992; Steele and Court, 1996; Yates and Stone, 1992).

White (1995) is of the opinion that most approaches to risk management appear to adhere to the generic process regardless of the various systems that have been proposed, and adds that this process comprises three crucial steps:

1. The risk identification phase which focuses on determining all risk factors that may arise in a project.
2. Risk analysis for the purpose of recognising the probability and the degree of the most important risks.
3. Risk evaluation focusing on deciding the most suitable management strategy to deal with every risk and the most suitable team to manage the risks identified.

In their study of risk evaluation problems, Li and Liao (2007) reveal that different types of risk factors which influence the operation of partners have been identified, and the measurement of their extent is determined by three elements; the chance of risk incidence, seriousness of consequence and control of the level of risk. These elements are represented by trapezoidal fuzzy numbers.

Figure (3-3) demonstrates the four stages which constitute the risk management process of dynamic alliances:

Figure 3-3 Risk Management Process of Dynamic Alliance (Li and Liao, 2007).

The risk identification phase forms the platform on which the whole process of risk management rests, and focuses mainly on identifying all types of risks factors, be they obvious or potential, by way of analysing an extensive amount of credible information. The working team bears the responsibility for doing so throughout the business activities of all alliance members.

The risk measurement phase is set to pinpoint the level of risk in each factor based on risk identification, and risk evaluation aims at estimating the overall scale of alliance by way of applying different approaches and technologies such as expert scoring methods, the AHP/ ANP method, and fuzzy inclusive evaluation, among others. This phase is also highly important in the risk management process and should be taken seriously as any incorrect estimation can lead to the alliance missing out on lucrative market opportunities, and any neglect of risks may end in needless losses.

The next phase that follows estimation and evaluation is referred to as risk prevention and control, and it is the part of the process where the focus is on the reduction of both risk incidence likelihood and the level of loss.

The final stage of the process is not only put in place to scrutinise and assess risk prevention and control performances, but also to fine-tune risk factors and to alter the means used in risk prevention and control so as to acclimatise to new circumstances.

3.9 Risk Identification

It is possible to suggest that the risk identification stage is crucial in the risk management practice as it is a key factor in raising decision makers' awareness in regard to occurrences which potentially could lead to uncertainties. In other terms, risk identification is principally set to pinpoint future possible insecurities enabling decision makers to engage in dealing with them effectively.

Risk identification in a network environment must recognise that organisations are interdependent and that deducing uncertainties within or outside the network depends on an effective system of information sharing. However, for the latter, this is not always the case as there are times when information is restricted to within the circle of the alliance and this can lead to the possibility of the views put forward in the collaboration being exaggerated or undervalued. Furthermore, due to the nature of enterprises in collaboration being owned by various members, and as previously mentioned in this section of this thesis, network risks not solely depending on a single enterprise's aims and objectives, network related risks can be difficult to identify (Hallikas et. , 2004).

It is possible to suggest that the process of reducing risk within a virtual organisation would be made much easier by identifying risk sources to begin with, followed by establishing links between them in a way that is founded on probability and impact.

3.10 Risk Sources

Risks can derive from various sources leading to divergent views about what determines them. Manson-Jones and Towill (1998) identify three types of risks in supply chains:

1. Internal risks in operation, such as accidents, non-reliability of equipment, loss of data, individual errors and quality issues; risks occurring as a direct result of managers' decisions such as choosing the size of consignment, safety of supply levels, monetary issues and delivery plans.
2. Risks that occur outside the organisation, but affect the supply chain. These may come to exist amid the interaction between the players in the supply chain, and can be divided into two categories; risks related to suppliers such as reliability, availability of materials, delivery and

schedules issues and industrial incidents, and risks related to clients as in for example problems with payments and order processing, changeable demands and tailored requirements.

3. External risks can also be environmentally determined as they can result from factors such as accidents, severe weather conditions, regulations, crimes and wars.

Dealing with the same problem, Zsidisin et al. (2000) assert that the sources of supply chain risks derive from issues in relation to design, quality, cost, availability of produce and production, supplier, legislative and environmental problems, and health and safety matters.

Johnson (2001), on the other hand, examines the view of risk sources from the buyer-supplier perspective suggesting that they are principally instigated as either supply risks or demand risks.

In classifying risks sources in relation to supply chains, Jüttner et al. (2003) propose three types of sources: external, internal and network related as illustrated in figure (3-4).

It appears that external risks are influenced by factors such as the social and natural environment, politics and the industry market, whereas internal ones are determined by factors such as actions of the workforce in the case of strikes, production failure related to machine failure, and IT system setbacks. Furthermore, network related risks result from interactions between organisations inside the supply chain.

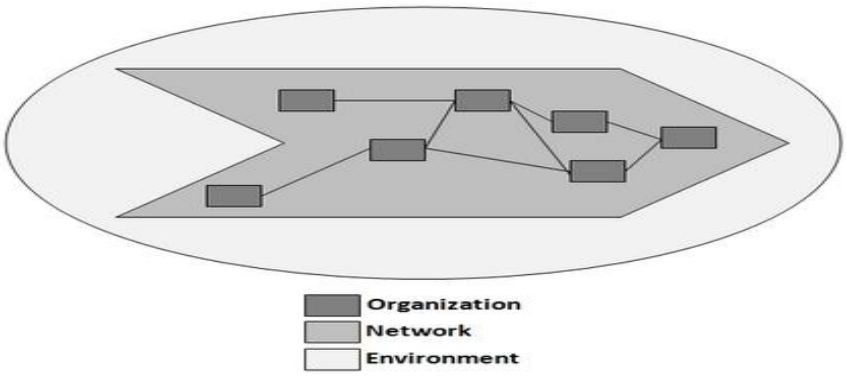

Figure 3-4 Supply Chain Risk Sources adapted from Jüttner et al. (2003).

Peck (2005) identifies four various and related aspects of risk sources in terms of supply chains exposure and pliability.

The first aspect is referred to as ‘work flow and information flow’ and deals with value stream, produce or procedure. At this stage, the supply chain is viewed as a logistics tool and takes into account that supply chain performance is the main aim. This approach tends to cause more risks in the supply chain.

The second aspect or level is concerned with assets and infrastructure dealing with ‘fixed and mobile assets’. The focal point here is on the role of the supply chain as a haulier of merchandise and data where its vulnerability may be evident in production locations, delivery centres and warehouses, in the use of IT and other communication means, as well as across the complete haulage network from supplier to customer.

The third level focuses on organisation and inter-organisational networks in terms of contractual and trading relationships. Here, organisational management, power distribution, collaboration and competition are vital elements in vulnerability assessment.

The fourth level is related to the environment, both the social and natural, and highlights political, economic, social, legal and technological elements which are not usually controlled by the company, but which nonetheless have to be resolved.

Peck’s model demonstrates that a resilient network incorporates more than just design and the management of vigorous supply chain procedures; a factor that makes it an exceptionally useful instrument to use to explain the extent and dynamic nature of supply chain risks. It also acknowledges that both supply chains and their risks are dynamic in nature and subject to a continuous evolution which makes the attainment of resilience in supply chains continually challenging.

In their study, Cheng and Kam (2008) reveal that the dynamics of risk in network systems are reliant on the type of the network, as well as on the practical role of every collaborator within the network arrived at by agreements on supply and inducements, and supply performance. They go on to suggest four categories in relation to risk factors: environmental risk, infrastructure risk, service delivery risk and organisational and relationship risk.

In the managerial process set to tackle supply chains risks, Jüttner et al. (2003) put forward four essential sequential steps that are interlinked as described in figure (3-5) below; risk sources, consequences, risk drivers and mitigation strategies. That is to

say risk sources result in unfavourable consequences which are prompted by risk drivers that may be counterbalanced by mitigation strategies.

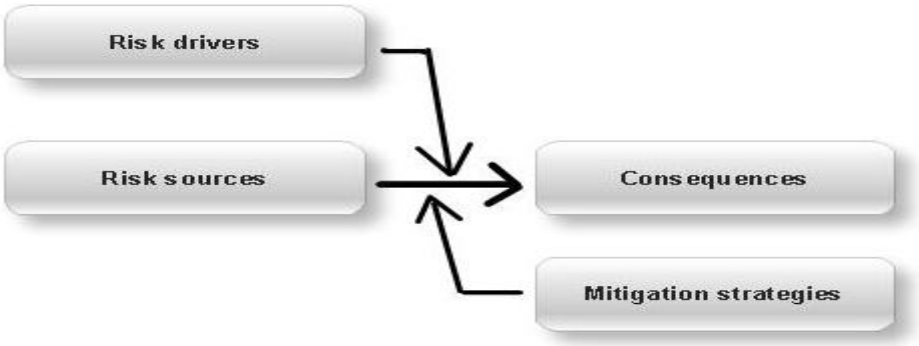

Figure 3-5 Supply Chain Risk Management adapted from Jüttner et al. (2003).

There are other risks that may occur within supplier networks. These are evident in for example the loss of know-how and the mishandling of data as a result of actions taken by individuals within the network who might be tempted to serve their own personal agenda. As well as this, there may be some cultural differences among partners which in turn may result in an undesirable impact on the nature of trust shared within a network in terms of collaboration. This also may provoke internal antagonism towards cooperation from both staff and management (Zanger, 1997).

Rigby (1996) outlines the risk of project failure which may be attributed to cultural discrepancies or the lack of a unified structure and objectives which would normally connect two parties.

Wynstra et al. (2001) suggest another widespread risk source which is defined by the inability to engage in product development collaboration by the chosen suppliers.

In evaluating risk sources and in the light of this literature review and preceding studies, it is safe to state that, as noted in the Jüttner et al. (2003) classification, risk sources in a network are different because of different relations among supply chain partners and virtual organisation partners but internal and external risk sources are similar.

Cavinato (2004) lists five sub-chains in every supply chain in relation to risks identification and uncertainties and these are:

1. Physical: this involves the movements and flows inside and between enterprises in terms of transportation, mobilisation of services, delivery, storage and inventories.
2. Financial: this refers to cash flows between organisations in relation to expenses, use of investments for the whole network, settlements, A/R and A/P procedures and systems.
3. Informational: this incorporates procedures and electronic systems, information movement stimulus, access to important data, collection and use of information, enabling processes and market intelligence.
4. Rational: this entails the correct coordination between a supplier, the organisation and its clients to maximise gains, and involves internal supply relationships issues throughout the organisation.
5. Innovational: this involves processes and links across the enterprise, its clients, suppliers and resource parties with the aim of discovering and bringing product marketing, service and process opportunities.

Kent (1992) asserts that supply chain risks can occur at four different levels: organisational, network, industrial and environmental.

The main focus of this study is risk sources in relation to networks, and the risk sources that fit into the second category of risk sources as suggested by Gaonkar and Viswanadham (2007). These risks are divided into two types: the first type suggests that firms are exposed to attacks targeting their assets as well as their suppliers, clients, transportation providers, lines of communication and other aspects in their environment. The second type indicates that firms are equally exposed to unreasonable behaviour from their network partners as in for example sharing classified information about product design with an opponent manufacturer.

Jüttner et al. (2003) is of the view that supply chain risks can be directly attributed to the supply chain structure itself. In other words, the sources of supply and demand risks are rooted in supply chains and are likely to impact on the interdependent parties involved in the chain. In addition, demand and supply risks in terms of them being internal supply chain risk sources, suggest that the responsibility for SCRM implementation can be in the hands of any company within the supply chain and that, at the same time, the enterprise itself can be a source of risk to the supply chain.

Bandyopadhyay et al. (1999) assert that the IS environment within an enterprise consists of three levels:

1. The application level: This level focuses on the risks in relation to technical or implementation failure of IT applications. These risks can result from both internal and external sources (Rainer et al., 1991).
2. The organisational level: At this level, the focal point is the impact of IT throughout all functional areas of the organisation and not just any isolated application. Noticeably, businesses are increasingly utilising IT at this level to remain competitive. Lightle and Sprohge (1992) present three types of organisational risks from the internal auditors' perspectives: sustainability risk, data security risk, and legal risk.
3. The inter-organisational level: This level involves the IT risks of organisations which operate in a network environment. The most prominent use of IT nowadays is evident in networks that exceed any organisational limitations. These are normally automated IS shared by two or more organisations. The increase in the use of these inter-organisational systems has helped to increase productivity, flexibility, and competitiveness (Cash et al., 1988).

Das and Teng (1996) argue that risks in strategic alliances can be independently isolated as relational risk and performance risk. They go on to define relational risks as the probability and the consequences of not totally adhering to the cooperation requirements.

These kinds of risks can be triggered by the possibility of opportunistic behaviour from any two or more firms. Opportunistic behaviour can be tied down to matters such as minimising information, cheating or otherwise distorting information and so on. This in turn can lead to conflicts as the individual interests of a firm may not be compatible with those of their partners. Khanna et al. (1998) refer to the benefits that ensue to one partner only as 'private benefits' and argue that they are a source of interest conflicts.

Furthermore, there exist several additional factors which may negatively impact on alliance performance. These factors may include new entrants, intensified competition, fluctuations in demand, changed government policies and incompetence

of one of the partners. These factors are responsible for performance risk, or the probability and consequences that alliance objectives are not achieved, despite satisfactory cooperation among partner firms (Das and Teng 1996).

Ratnasingam (2006) examined perceived risks of e-commerce in supply chain activities, where he identified and developed a conceptual model based on previous research identification of four types of risks, namely technological, organisational, implementation, and relational risks.

1. Technological Risks: Bhimani (1996) argues that technological risks can be caused by integration issues such as incompatible applications or lack of security which in turn impacts on confidentiality, integrity, and authentication of supply chain transactions.
2. Organisational Risks: are associated with the degree of top management involvement and pledges of resources and financial capital. Primary start-up costs for implementing SCM e-collaboration applications require high capital investment that includes connection costs, hardware, software, set-up, and maintenance costs (Commercenet, 1997; Iacovou et al., 1995; Nath et al., 1998).
3. Implementation Risks: are caused by the presence of non-uniform standards and inconsistent government policies which in turn impact on SCM performance. These can also be increased as a result of lack of technical know-how skills and training (Premkumar, 2003).
4. Relational Risks: are mainly caused by lack of experience in security, concerns about the capacity to audit e-collaboration systems, task uncertainties, environment uncertainties and false impressions of unreliability.

Uncertainties occur in the case of supply chain partners stumbling upon obstacles in communication such as incompatible SCM systems, or lack of uniform standards and this may result in conflicts (Claycomb and Frankwick, 2004; Domke-Damonte and Lensen, 2002).

Sinha et al. (2004) present four points of risks which involve standards, suppliers, technology and practices, and a number of supply chain risks may occur at each of these points.

Finch (2004) splits risks into three categories including three levels of coverage; application level, organisational level, and inter-organisational level. The application level incorporates aspects such as natural disasters, accidents, premeditated acts, data/information security risks, and management issues. The organisational level refers to risks such as the legal and strategic alterations in decisions that could happen, whereas the inter-organisational level is where possible uncertainties from the outside of the organisation could pose risks.

3.11 Risk Assessment

Assessing a risk marks the step that precedes risk analysis whereby risks are evaluated and their outcomes are estimated. Statistical methods, in the view of Hamilton (1985), ought to be deployed to pinpoint the likelihood of a risk happening, its outcomes and its level in the sense of it being acceptable, unacceptable or catastrophic. Therefore risks have to be graded in accordance with the seriousness of their consequences since they impact and disrupt the supply chain. Norrman and Jansson (2004) propose more possibilities for quantitative analysis of risks, and Jüttner et al. (2003) confirm that the industry in which an enterprise is engaged is what partially determines risks in relation to their significance. However, quantitative risk analysis on its own can be inadequate. This is to say that if risks are solely evaluated via the process of multiplying their size with their occurrence, in terms of value, smaller risks that take place more frequently may be just as catastrophic as those that scarcely ever happen (Giunipero and Eltantawy, 2003).

Harland et al. (2003) adopt Mitchell's description of risk (R) as the product of the probability (P) of the loss and the impact (I) of the loss related to an event (n);

$$\boldsymbol{Risk\ n\ =\ P\ (loss\ n)\ x\ I\ (loss\ n)}$$

On this basis, they identify six types of loss: financial loss, performance loss, physical loss, psychological loss, social and time losses.

Norrman and Lindroth (2004) put forward a three dimensional outline to assess and classify supply chain risks. Each dimension stresses various aspects of research matters or managerial responses and these are: the supply chain itself, risk management processes and the nature of risk. In so far as the first dimension is

concerned, the focus is on analysing the unit, taking into account the single logistic activity internally and externally, and the complete supply chain. The second dimension emphasises the degree of risk management activities; a process which is initiated by identification of risk and ends with business permanent management. The third dimension involves types of risks that may be of various natures and, therefore, may not be eligible for analysis within the same study.

Deloach (2000) suggests different categories of risks: externally driven risks or environmental risks and includes competitors, clients and regulations; internally driven risks are considered in relation to operations and processes. The latter can be instigated by wrong decisions or lack of information.

In the view of subcontractors, a conceptual framework of risk analysis and assessment for production networks has been proposed by Hallikas et al. (2002) with the main objective of unravelling the manner in which SMEs can carry out assessments and analysis of business risks associated with networking.

Risk assessment and prioritisation are a must in selecting appropriate actions to identify risk factors in accordance with the situation within the enterprise or the network.

Faisal et al. (2007), assert that risk in supply chains can be lessened via the integration of the analytic network process (ANP) approach and supply chain operations reference model (SCOR). Their model advocates that supply chain managers should continuously take into account various types of risks, their inter-reliability and the feedback that has been put in place, in order to choose the most favourable alternative in the management of risks. In addition, the use of SCOR in the development of an ANP based framework for the purpose of mitigating risks in supply chains, considers indirect relationships and the existing complex interactions in the supply chain risk variables.

By analysing potential risks which take place in any given period within the life span of the virtual enterprise, Liu et al. (2007) have established a system for the identification of groups of risks. This is founded on the theory of fuzzy mathematics and has been adopted for the evaluation of project risks of virtual enterprise.

3.12 Risk Management Strategies and Mitigation Plans

Strategically, risk management aims to identify and assess the probabilities and the aftermath of risks, and to enable the selection of suitable approaches to minimise the probability of losses related to undesirable events. Risk mitigation aims to limit the consequences in the event of undesirable happenings (Norrman and Jansson 2004).

In their view of risk management strategies, Jüttner et al. (2003) and Miller (1992) identify seven major categories which are avoidance, postponement, speculation, hedging, control, sharing/ transferring and security.

Hallikas et al. (2004) illustrate the structure of the risk management process and put forward their methods in a multifaceted network milieu. Their study is intended to contribute to offering more of a complete understanding of risk management in suppliers' networks. For example in the case of dependency increasing between enterprises, an enterprise may become more susceptible to risks evoked by others within the network and hence become in need of the above proposed process to help with facilitating understanding and managing uncertainties and risks in supplier networks.

On the whole, risks within a network milieu can be managed via the adaptation of a common strategy in addition to appropriate practice modes of actions and contract policies. Notably, it is the identification of risks and their assessment that shed light on what course of actions are to be taken. While some risks can be collectively lessened in the network, others have to be solely managed by each partner. The diversity of objectives of various networks in a multi-network milieu can instigate contradictions for an enterprise, and this is the moment when the actual assessment of risks can assist the enterprise in deciding how to best function in these circumstances.

The nature of network relationships at times increases the need for transferring risks from one company to another, and this may only work if the company receiving the risk can deal with it better than the one who has initially transferred it.

Let us consider the risk of investment as an example to better understand the concept of risks transfers. The likelihood of an investment failure may decrease if the supplier can use it in many networks or client relationships. However, at times, the impact of

transferred risks may be greater for the risk-taking suppliers than for the original equipment manufacturer.

The main objective of network extended analysis is to find the best possible risk management strategies to share and to weigh up risks at the network level. It is also important to note that the nature of risks is subject to change due to the enterprises and their milieu being changeable, and known risk factors may be monitored to pinpoint the possible trends in their probability or aftermath.

Another framework for managing uncertainty in supply chains is proposed by Cucchiella and Gastaldi (2006) to minimise a company's risks. They suggest that one way of limiting damages caused by uncertainty is to increase the degree of flexibility within the supply chain via the use of the real options theory as it allows an increase in the level of flexibility.

Chen and Chen (2006) suggest three types of procedures to mitigate high risks in the collaborative process and these are partner selection, cooperation contract design, and coordination mechanism design.

Finch (2004) views supply chain risks management from an inter-organisational networking angle, and emphasises the need for enterprises to appropriately plan to ensure continuity in business. This may include matters resulting from processes within or outside the organisation.

Christopher and Lee (2004) suggest methods that are controlled within and by the organisation and stress the need for improving supply chains as mechanisms to mitigate risks.

Norrman and Lindroth (2001) identify four major techniques in relation to the management of risks: risk sharing, transferring, reduction and avoidance.

Risk sharing is attained via contracts and improved cooperation among members of the supply chain, and risks may be transferred to suppliers by 'just in time deliveries' and made to order contracts, as well as outsourcing. Risk reduction can be attained via a number of different methods and strategies (Norrman and Jansson, 2004).

Miller (1992) puts forward five elements related to risk management: control, cooperation, imitation, flexibility and risk avoidance. The first four are seen as

techniques for the purpose of reducing risks. In order to control uncertainties, companies engage in political lobbying to establish market power and, hence, control competitors via various means. On the other hand, cooperative strategies tend to be less strict than control and incorporate contracts and alliances between various companies where the level of interaction is not as strong as the cooperation at the time of risk sharing. Imitation entails adopting similar approaches used by other companies such as pricing and product development for the purpose of reducing risks. Flexibility is achieved by diversifying product lines and by adequately using various and numerous suppliers.

In so far as avoidance is concerned, if a risk is classed as unacceptable, the company must therefore avoid the product, geographical location, supplier, or the client organisation which instigates the risk as suggested by Norman and Lindroth (2001).

3.13 Conclusion

The idea behind this chapter is to help with the understanding of risk management in VOs. It has also emerged in this study that most enterprises operate within more than one network and each enterprise sees risks in a different manner. Also, it can be said that where enterprises are dependent on each other, risk transfer and sharing inevitably occur in the VO. It should be remembered that an increase in dependency between enterprises may mean that they are more exposed to risks adhering to other enterprises.

Networking also increases the partners' responsibilities and sometimes investment risks may be transferred to partners

The process of risk identification is a crucial stage of the overall risk management process as, in networks, risk sources may derive from complex chains and can be hard to perceive. It is also important to acknowledge that the dynamics of relationships and their development can cause extra difficulties. Therefore, enterprises should clearly communicate and share their views on risks as this may help enhance their understanding of common opportunities and threats in a more holistic manner. In turn, the enhanced understanding can lead to better decisions and can lessen risks of single organisations and networks.

Chapter 4 Methodology

4.1 Introduction

Having conducted a review of the literature in the previous chapter, this chapter will detail the methodology used to conduct the research. In the first section there will be an introduction with the second section having a summary of the SYNERGY project, details of the consortium of partners, and of the activities of the project. In the third section the research objectives will be summarised and in the fourth and fifth sections the design of the research and the approach that is taken will be discussed. Section six will deal with the research methods used for this thesis, describing how the research has been undertaken using a combination of qualitative and quantitative methods and providing a summary of Warfield's ISM and Saaty's ANP. The validity and reliability of the research will be discussed in the seventh section of the chapter before the conclusion to end the chapter.

The literature makes clear that the problem that is being discussed is hypothesised as being within the area of risk. The research that this thesis describes is applied research aiming to find practical solutions to a problem that exists in reality rather than being research that is concerned with theory only. The opinion of Hakim (1987) is one with which the researcher agrees, namely that the difference between research into theory and research into what she calls 'policy', in reality exists only as a matter of emphasis. According to her the chief aspects distinguishing policy research from theoretical research are as follows:

"an emphasis on the substantive or practical importance of research results rather than on merely 'statistically significant' findings, and second, a multi-disciplinary approach which in turn leads to the eclectic and catholic use of any and all research designs which might prove helpful in answering the questions posed" (Hakim, 1987).

The literature review, as previously stated, is crucial to the research, since it provides the information that allows the researcher to come to a definition of the problem which is being researched into, and it is therefore usually the initial step for any research study and that applies to this study also.

Since the 'body of knowledge' relating to most subjects is continually growing, the thorough researcher will return to the literature since the process of reviewing it is a dynamic aspect of the methodology, and it is important that it is kept clearly in mind that the knowledge relating to any subject may well be added to in the interval between obtaining the information for any research and writing it up.

The phrase "research methodology" refers to the methods used to undertake research as well as to the logic that underpins those methods. However, each key concept that is to be assessed though use of the research methodology must be fully understood and the framework for the formulation of the results must be defined, before the methodology to undertake the research can be devised. This is also an aid in reaching an understanding of the information that needs to be collected in order to address the problem or for meeting the research objectives. The main issues with which this research is concerned are the sources of risk that are intrinsic to VO collaborations, how they relate to each other and how important they are.

The area to be researched for this study is complex and challenging and therefore the design for it needs to be innovative in order to meet the challenges. A systematic approach was taken to this task, using the research methodology which will be fully explained in this chapter.

In order to undertake this research it has been necessary to use both quantitative and qualitative methods for the study of the research objectives. For this reason there is a focus on the collection and analysis of both quantitative and qualitative data. In order that a balanced check could be developed, this research was divided into four phases:

1. Identification of risk sources in virtual organisation collaboration through the use of the literature review and a questionnaire to collect the opinions of experts.
2. A questionnaire survey to collect information for Interpretive Structural Modeling (ISM).
3. A questionnaire survey to collect information for Analytical Network Process (ANP).
4. Data collected from interview that was based on case study.

In the second section the SYNERGY project is discussed together with its aims, the consortium and the activities undertaken, in order to show that this research is aiming to meet one of the SYNERGY project objectives.

4.2 SYNERGY Project

SYNERGY (Popplewell et al., 2008) "Supporting Highly Adaptive Network Enterprise Collaboration Through semantically enabled knowledge services" is a three years European funded Seventh Framework Research Project which was started in February 2008. It carries out research into what is needed by those stakeholders who working in collaboration within partnerships that are based on VO business models in order to ascertain the support that they need in the areas of collaboration and knowledge sharing.

The aim of this project is to bring about more efficient knowledge sharing between organisations and to encourage collaboration by using an extremely intelligent technological system that uses as its basis patterns of collaboration and of the sharing of knowledge. Its aim is to provide better support for the connected companies so that they will be able to create a collaborative VO at the appropriate point, and also to provide them with the necessary services and infrastructure to enable them to find out, access and retain the information that is necessary, firstly for the creation of the collaberation and, secondly, for its success.

Figure 4-1 SYNERGY Vision of Knowledge Oriented Collaboration (Popplewell et al., 2008)

Figure (4-1) illustrates the overall idea of the SYNERGY project in terms of the TO-BE situation enabled by the SYNERGY project results. The TO-BE situation which is a Web-based and service oriented software infrastructure will give assistance to a range of companies who are having to become part of collaborative businesses in order to allow them to discover, assimilate and subsequently deliver and use knowledge that is important for the construction and operation of a collaboration, so that they will be better able to be part of a VO while at the same time being able to circumvent the problems and shortcomings mentioned above using as its guide the ideas and approaches of the First Enterprise Interoperability Research Roadmap (Li et al., 2006), the structure of SYNERGY addresses and refines the first significant challenge which is the Interoperability Service Utility (ISU); the SYNERGY project

offers all its services by way of a platform that is open and directed towards service so that all companies involved and, in particular SMEs, can use the intelligent infrastructure support that is offered independently in order to help them to plan and then set up and afterwards manage knowledge-based collaborations that are intrinsically complex.

4.2.1 The SYNERGY Consortium

The SYNERGY consortium is made up of 8 partners from 6 European countries and is therefore able to offer a great deal of pooled experience and skills which they bring to the project in order to ensure the success of ambitious project objectives. The SYNERGY partners are as follows:

1. Coventry University, Coventry - United Kingdom, the Coordinator.
2. Forschungzentrum Informatik An der Universitaet Karlsruhe, Karlsruhe-Germany.
3. The Institute of Communication and Computer Systems, Athena-Greece.
4. Cim College D.O.O., Nis-Serbia.
5. Loughborough University, Loughborough-United Kingdom.
6. Douglas Connect, Zeiningen-Switzerland.
7. Technology Application Network LTD, Preston-United Kingdom.
8. EBM Websourcing Sas, Saint Agne-France.

4.2.2 SYNERGY Activities

Figure 4-2 SYNERGY Work Packages (Popplewell et al., 2008)

- Laying the cornerstones: the consortium coordinator leads WP1 in which all partners take part and which generates for all of them a shared understanding of the project as well as undertaking a wide-ranging collection of requirements and inputs which is analysed. This is taken in particular from those cases using SYNERGY. Subsequently the overall conceptual framework is defined so that it is able to provide a ‘map’ for the ‘landscape’ that is to be created and examined in greater depth in later technical WPs.
- Knowledge-Based Collaboration in a static world: In the light of what is required but also within the boundaries established by the basic decisions stemming from the WP1, it becomes possible to work on the three major scientific challenges of SYNERGY in relation to a static world.
- The WP2, WP3 and WP4 are refined further using the required knowledge and the meta knowledge structures. Procedures are then identified and put into place as well

as solutions for Collaboration Knowledge Services, Collaboration Moderator Services and Collaboration Pattern Services.

- Knowledge-Based Collaboration in a dynamic world: Once there is a sound understanding of the static case and a partial solution, it is possible for WP6 to begin to work on developments such as higher order learning and other aspects. Put together the results of WPs 3, 4, 6 make up the nucleus of a mediation infrastructure that is intelligent, able to modify itself and open to continuous improvement to enable it to function in a knowledge-based collaboration network, in effect the Learning VO.
- Orthogonal Service Work packages: this comprises two work packages that are to some extent orthogonal to others which will either provide services for the core technology research WPs referred to previously or else extract and process further results from them (as well as the Project Management WP11 which is not shown in the figure).
- WP5 (Knowledge Formalisation) begins at the point where all requirements have been stated and the most fundamental situation and decisions specifically related to content, have been taken; what it gives is the ontology that is needed and a foundation for knowledge management to other WPs.
- As well as this, at a late stage in the project the results of the research relating to the core technology are taken by WP7 (Software Integration) and integrated into the overall SYNERGY software; where it is needed WP7 can also make available third party software.

This research is related to the second objective in WP2 (Collaboration Knowledge Services Objectives) the objectives of which are:

1. To provide a definition of the construction and range of the materials and services necessary to manage sharing and security within collaboration models existing in enterprises either across networks that are already in existence or across potential network enterprises, across industrial sectors or even having a wider range.
2. To give support to evaluate collaboration as well as the risks that exist for network enterprise collaboration, to provide the means to carry out assessment of risks across the network, and to analyse the results of those

calculations that impact on either the network or the partners in enterprises.

3. To provide the means for the identification of the sources of the knowledge that is available for collaboration as well as a methodology and the means to acquire these from the sources.

4.3 Research Aim

The aim of this research is to identify those risks that are intrinsic to collaboration between SMEs, to identify any relationships between the sources of those risks and to identify what potential impact they have, a further contribution is made by use of tools (ISM and ANP) to enable SMEs to understand the inter-relationships of risk sources and in that way, to provide a means to manage such risks.

From the research objectives (Section 1.2) and the summary of the SYNERGY project's activities it is clear that this research will satisfy the second objective in the second work package (WP2) of the SYNERGY project.

4.4 Research Design

According to Kothari (2005) research methodology provides a means of systematically solving the research problem as well as providing an underlying structure for the research process by means of taking logical steps through the appropriate stages.

This research methodology has been planned in such a way that it will achieve the research objectives though the use of the effective collection of data and its analysis together with validation of the same. This procedure will make possible the continuous collection of the knowledge that is necessary for the research process.

Where the purpose of any research is clear, it is possible to put in place a suitable research design, although it should be noted that research design is not the same as data collection. The design of the research is able to impose a logical structure on it, while the data for the research can be collected by any available method for data collection, since how this happens is of no relevance to the design (DeVaus, 2001). According to Yin (1994) research design "deals with a logical problem and not a logistical problem" which means that it is different from a work plan which will state

what needs to be done but which has only been arrived at as a consequence of the research design. In a definition of research design DeVaus (2001) states that "The function of a research design is to ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible".

For meaningful research, relevant evidence must be amassed in order to address the research question(s), to test theory (ies) and to prove the hypothesis in a way that will withstand scrutiny. For this to happen, decisions must be taken in relation to what types of data must be collected and analysed and what methods should be used. Both the number and type of the methods that are to be used will usually be described in the research design (Sarantakos, 1998).

Yin (1994) suggests that the starting point for the researcher should be a theoretical proposition since this makes it easier to devise the research design, decide the data that should be collected, and what technique(s) should be used for analysis.

Where use has been made of a wider literature base so that ideas that are not normally linked are brought together, such as VO, ISM and ANP, it provides "a theory with stronger internal validity, wider generalisibility, and higher conceptual level" (Eisenhardt, 1989).

In the case of this research, as well as drawing on wide-ranging literature, a number of methods for the collection of data were also used. It is vital that the research strategy should be well-chosen in order to gather the information for the sources of risk in VOs which are being investigated here.

Generally, six types of research strategies exist, which include experiment, survey, case study, grounded theory, ethnography and action research (Oppenheim, 1992). For this research the survey method and case study were chosen. For research to be well-designed, it must use a method as well as far-reaching tactical planning that will allow for the investigation, sampling and collection of the data that the study will need (Bernard, 2000).

There are two types of data that will need to be collected; primary and secondary.

4.4.1 Primary Research

Primary research is the collection of fresh, previously non-existent data which the researcher will have to undertake for himself.

The collection of primary data has important advantages compared with other methods (Brace, 2004; Saunders et al., 2009). Primary research can gather first hand information and therefore information that has never been used before becomes available. In general there are two methods for the collection of primary data and these are the use of questionnaires and of interviews (Saunders et al., 2009). The first phase of this research makes use of a questionnaire, which is itself a structured sequence of questions which have been devised to elicit facts and opinions thereby establishing a base for the recording of data (Hague, 2002). A number of factors must be taken into account when designing a questionnaire (Oppenheim, 1992):

1. The type of research.
2. The sample size.
3. The characteristics of the sample.

To gather the required information from the respondents two types of question can be used: open questions and closed questions.

For this research use was made of closed questions in the questionnaire and open questions in the case study, based on findings from secondary research. In this way the use of relevant and appropriate questions was ensured.

4.4.2 Secondary Research

Secondary research is the examination of data that has previously been collected by another person and it is used when a summary or collection of existing data is necessary for the research. Such secondary sources might include reports from previous research, the content of journals, conferences and books as well as other sources. On occasion it is necessary to undertake secondary research in the preliminary stages of a research in order to make clear what is known already and consequently what new data might be necessary, or else as a basis for the research design.

Secondary research should precede primary research since if the secondary research is not carried out, primary research which could involve considerable expense might be commissioned only to give information that might have been gathered from previously existing sources (Mort, 2003; Hague, 2002). For this reason secondary research must be undertaken before any primary research is embarked upon.

For this research, secondary data was gathered from online sources, and from a number of publications including textbooks, conference papers and journals before the primary research was undertaken.

Advantages provided by secondary data are the saving of time and money and the fact that it can yield data for both comparison and context (Saunders et al., 2009). It is also the case that where secondary data is analysed again, it can lead to the uncovering of unexpected new facets.

The disadvantage attaching to it is it may have been collected for a different research purpose, which will not be the case with primary data and therefore it may not be applicable to the research question in hand, or it may, quite simply, be out of date.

The collection of data embraces the use of both primary and secondary data and according to Yin (1994), while no one single source is better than another, there must be a combination of the two to arrive at the appropriate information.

4.5 Research Approaches

The phrase ‘research approach’ includes within it the terminology, tools, and instrument and all other means that are used to examine the various factors that come into use once the design of the research has been decided upon.

Within the social sciences there are two fundamental approaches, these being the quantitative approach and the qualitative approach, the difference between the two having been an issue for academic debate between researchers over recent decades (Bryman, 1988).

Within the literature disagreements exist as to the value and use of quantitative methods as compared to qualitative methods. From this fact it may be inferred that whether quantitative and/or qualitative data is likely to be of greater use is dependent on what precisely is being researched and from what perspective. In almost all areas

of social research, and this includes areas such as education, business management and others, research designs have been formulated mainly, if not exclusively, on qualitative rather than quantitative data and this is now accepted as being acceptable and, indeed, respectable (Robson, 2002).

Nevertheless, it is still accepted that research designs will choose to use either one or the other so that social surveys, for example, are more likely to be regarded as being quantitative research, making use of statistics in a quantitative method and for the resulting analysis, whereas case studies will be seen as being undertaken using qualitative research, using interpretation in the analysis of data and examining elements of the study in their context and taking into account people's subjective meanings (DeVaus, 2001).

According to Bellenger and Greenberg (1978) the qualities of good research are as follows (Kothari, 2005):

1. Good research is conducted systematically, which means that the necessary steps are specified and are then followed in a specific sequence and adhering to a defined set of rules. However, because the research is conducted systemically, this does not mean that creative thinking is excluded. What is excluded, though, is the use of guesswork and intuition to arrive at a conclusion.
2. Good research uses logic which means that it is conducted using the valuable methods of logical reasoning as well as logical processes of induction. A definition of induction is the use of reason to progress from a part to the whole, while deduction means that a conclusion is reached that follows directly from a specific premise. Where research is to be used for the purpose of making decisions it is of greater value where conclusions have been arrived at as a result of logical reasoning.
3. Good research is based on experiment and observation which means that it essentially relates to a real situation in one or more ways and deals with empirical data so that the research results can be externally validated.
4. Good research can be reproduced which means that its results can be verified by an exact repetition of the study, which gives a solid base for making decisions.

4.5.1 Quantitative Data

Bryman (2001) defined quantitative research as a distinctive research strategy that makes use of the "... collection of numerical data and exhibiting a view of the relationship between theory and research as deductive, a predilection for a natural science approach, and as having an objectivist conception of social reality".

For quantitative research in this area the foremost method for the collection of data is the social survey which is able to generate quantifiable data relating to a large number of people who are selected in order to test hypotheses, and this is why it has been so widely used. The approach to a social survey is different from the principles of quantitative research as it is used in the sciences (Bryman, 1988).

In scientific experiments and descriptive surveys, as in any kind of research where categorisation is possible, what is being studied can be categorised in such a way that counting can be used, quantitative data is the primary data that is collected and the usual method for its collection is through standardised instruments for observation, such as questionnaires, carefully constructed interviews and other methods. The collection and analysis of quantitative data makes it possible to deconstruct complex issues and assign to them numerical values (Kerlinger, 1986). Since it exists in a numerical form, it is possible to easily analyse a great deal of quantitative data using computerised statistical analysis tools and programs, and therefore surveys can be undertaken using large population samples.

4.5.2 Qualitative Data

In contrast to quantitative data, qualitative data are "a source of well-grounded, rich descriptions and explanations of processes in identifiable local contexts" (Miles and Huberman, 1994).

Qualitative research has also been defined by Preissle (2002) "... as a loosely defined category of research design or models, all of which elicit verbal, visual, tactile, olfactory, and gustatory data in form of descriptive narrative like field notes, recordings, or other transcriptions from audio and videotapes and other written records and pictures or films".

Qualitative research aims to produce findings (Patton, 1990), and this will conclude with analysis and interpretation and then presentation of the findings. Qualitative data, on the other hand, is mostly made up of words and the data is analysed through the assembly and clustering of the words into semiotic segments which then enable the researcher to contrast, compare and analyse in order to recognise patterns that are occurring in them (Miles and Huberman, 1994). It also differs from quantitative data where it is possible to use digital programs for analysis, in that in cases where the study has been very large the volume of the qualitative data must first be reduced so that it becomes possible to identify patterns that are significant. This reduction of the data takes place continuously throughout the research, and even before it is actually collected anticipatory reduction is taking place since the researcher will be making decisions as to which cases and which research questions to use as well as which methods to put in place for the collection of data (Miles and Huberman, 1994).

The main sources for the collection of qualitative data are in depth, open-ended interviews, direct observation, and written documents. The data from interviews will, in the main, be made up of direct quotation where people talk about their experiences and feelings and give their opinion as well as divulging their knowledge, in response to open-ended questions (Patton, 1990). From the use of open-ended questions, the researcher is able to discover and understand people's points of view, without them having been predetermined through prior selection as is likely to be the case where they form part of a questionnaire category. Other sources of information are administrative and archival records (Yin, 1994). Concepts are developed through the use of qualitative data rather than concepts that are already established being applied, in order that phenomena can be understood and therefore explained; thus, qualitative research is, in essence, an investigative procedure.

Whereas samples collected for quantitative data tend to be random, those collected for qualitative data tend to be more purposive. This arises partly because the initial universal definition is more limited but also because there is a logic and consistency in social processes that could not be addressed by random sampling (Miles and Huberman, 1994).

It could be said that the differences between quantitative and qualitative methods represents a compromise between depth and breadth, with qualitative methods making

it possible for the researcher who seeks to evaluate to look at selected issues in greater depth and detail since no constraint is imposed by the categories to be analysed being pre-determined (Patton, 1990).

According to Strauss and Corbin (1990) there are three major components of qualitative research.

- Firstly, typical sources for data are interviews and observations and for this research an interview has been conducted with a representative of Control 2K.
- Secondly, analytic or interpretive procedures are used to conceptualise data, in this case, categorisation is used. For this research the answers and information provided have been categorised according to the themes in the research.
- Thirdly, written and oral reports are used.

The need for a deep understanding of some elements of the research has dictated that a qualitative approach should be used for this research. This deep understanding has been necessary in order to create a new architectural solution as well as a new theory for this subject.

The aim of qualitative research is to focus on problems in the real world with all the complexity that this implies. Qualitative researches do not often attempt to simplify the problematic situation that is being studied, rather they aim for a recognition of the fact that the problem being studied is multi-layered and has many dimensions and therefore they attempt to consider it from all angles and aspects (Leedy and Ormrod, 2010).

Woods (1999) states that a researcher using qualitative methods must bear in mind that such methods are the least prescriptive that can be used and therefore no strict guidelines exist for undertaking this kind of research.

4.5.3 Triangulation

It is usual for research to make use of only one basic methodology and taken from only one methodological context, that is the qualitative or the quantitative (Sarantakos, 1998). For a number of years many authors have vigorously opined that qualitative methods should be used rather than the quantitative methods that have

generally been dominant, although this view has, in turn, been forcefully argued against by those who support quantitative methods. The argument has also been made that this division between the two methods has created a line of demarcation that is artificial and has led to unnecessary conflict between scientists (Gummesson, 1991). Consequently a third group has been formed of those who argue for a combination of quantitative and qualitative methods. Where these different methods for the collection of data are combined for use in such areas as surveys and experiments, or observation and methods using documents, in order to examine the same social issue it is called triangulation and is used by both quantitative and qualitative researchers (Sarantakos 1998). It is held that triangulation is able to improve the rigour of research and enable the researcher:

1. To gather a range of information dealing with the same issue (Blaikie, 1991; Sarantakos, 1998; Robson, 2002).
2. The strengths in each method are able to compensate for the shortcomings in the other.
3. A greater degree of validity and reliability can be achieved.
4. The shortcomings of single method studies are eliminated.
5. Ease of interpreting the study is improved.

4.6 Selection of Research Method

This study makes use of two popular methods to fulfill its objectives, these two methods being the use of a questionnaire and a case study. The various types of research methods that are available were reviewed and the conclusion was reached that in order to achieve the objectives of the research the most appropriate method to employ was the combination of a quantitative method, through the use of a questionnaire, with a qualitative method, using a case study, so that methodological pluralism would be achieved (Ragsdell and Wilby, 2001), which can provide fuller data and therefore a more robust base for an analysis of the research findings. By using these two methods together an extremely effective mechanism is provided for the combination of both quantitative and qualitative research approaches. According to Krueger and Casey (1994), “increasingly researchers are recognising the benefits of combining quantitative and qualitative procedures, resulting in greater methodological mixes that strengthen the research design”.

Churchill (1995) states, “The problem as finally defined will often suggest one approach over the others, but the researcher should recognise that the approaches often can be used most productively in combination”. Nonetheless, there is no one best method for the collection of data and which method is chosen will depend on the nature of the research questions that are being asked and the particular questions that the researcher wants to put to the respondents. What all methods aim to achieve are answers that are valid and reliable in response to the questions asked, which have not been distorted by the methods used for collection and which are not subject to chance fluctuations (Wilson, 1996).

4.6.1 Questionnaires

The questionnaire survey was conducted in order to collect quantitative data and analyse it. A questionnaire is a list of questions that the researcher asks which is devised in such a way that each respondent is asked exactly the same questions. It may be administered in a number of ways: it can be completed by the respondent while the researcher waits, or else sent through the post to the respondent and then back to the researcher, or it may be completed online and sent by email; in the latter two cases it is likely to be completed without any supervision (Chapman and Mcneill and, 2005; Dane, 1990; Schonlau et al., 2002).

This questionnaire was administered by email and the advantages and disadvantages of using an electronic questionnaire are summarised in table (4-1) (Sekaran, 2003).

Table 4-1 Advantages and Disadvantages of Electronic Questionnaire (Sekaran, 2003)

A questionnaire that is sent through the post or using an email can be sent over a much wider geographical area than one that is administered personally. Cost can be minimised, both in terms of data collecting and of processing, and it is free from

having bias exerted by presence of the researcher. Since in this instance the experts that were to be questioned are located over a wide geographical area, the use of the internet to send the questionnaire was adopted.

The first email survey (see appendix 1 for a copy of the questionnaire) was administered to the members of SYNERGY group for the first questionnaire. Nine members responded to it from the sixteen members to which we sent the questionnaire to, giving a response rate of 53%.

The questionnaire was designed to be coded and therefore the coding process was carried out directly onto the questionnaire and then entered into the Statistical Package for the Social Sciences (SPSS) for statistical measurement.

The second and the third email questionnaires were distributed to the members of INTEROP-VLab which had 224 members listed. The work of these members is related to the VO which is essential for our study and for answering the questionnaires. From the 224 members we received 45 responses for the second and the third questionnaires where our sample was large in order to give greater reliability (Kothari, 2005). However, the return rates for these two questionnaires are typically low (Dane, 1990; Bourque and Fielder, 1995). For statistically reliable information a 20% response rate is considered adequate (Collis and Hussey, 2009; Adam and Healy, 2000; Brannick and Roche, 1997; fellows and Liu, 2002; Sekaran, 2003).

These questions were designed to obtain the respondents' views on the relationships and the weights of these risk sources. The respondents to the questionnaire must be able to understand the questions in the way that the researcher intends, have access to the information needed to answer them, and be willing to answer them, and actually answer them in the form called for by the question. It may therefore be necessary to alter the language of the question so that respondents find it understandable and unambiguous (Robson, 2002).

Questionnaires have both advantages and disadvantages. Table (4-2) illustrates the main advantages and limitations.

Table 4-2 Advantages and Limitations of Questionnaires (Robson, 2002)

The final disadvantage that a questionnaire has which can also be seen as the most serious one is that there is often a low response rate so that it is not possible to obtain an adequate rate of response. For this study this problem was overcome by sending the questionnaires to respondents who were experts in this particular field and therefore would be likely to be interested in this study, the first one being sent to the SYNERGY partners, the second and the third to the INTEROP-VLaB members.

In addition other important limitations of a questionnaire survey where it may be difficult to obtain in-depth or detailed responses were surmounted by supplementing it with a case study for the final phase of this research. The combination of these two methods has added to the strength to this study in a way which would not have been possible by using one method only.

The second and third questionnaires were used for ISM and ANP and the following is a summary of these tools.

4.6.1.1 Interpretive Structural Modeling (ISM)

The literature and expert opinion both from the academic world and from industry were used to identify the sources of risk to SME collaborations. Details of these identified sources are listed in chapter 5.

An analysis was made of the relationships between these sources of risk and the dependences and the driving power for each source in relation to the other sources in

order to provide a risk management contribution for those SMEs either planing to join a VO or already in one.

It demonstrated what the risk sources are that threaten a collaboration and also which sources would be likely to increase the risk from other sources. For this analysis it was necessary to examine the direct and indirect relationships between the sources rather than examining each one in isolation.

ISM technique has been applied to analyse the relations between these risks sources and to understand the dependence and the driving power of each risk's sources in relation to the other sources. ISM is a tool to facilitate management decisions through linking ideas in order to enable the understanding of complex situations. ISM is able to set up, examine and tackle general issues and problems. Warfield (1987) states that "it is a general system methodology in that its application is not confined to any discipline, but rather can be used to explore general issues and problems".

ISM is one of the tools of interactive management (Warfield, 1974). It provides an established methodology to identify and summarise the relationships between particular aspects, it is able to define an issue or a problem and it provides a means to impose order on the complexity stemming from these various elements (Mandal and Deshmukh, 1994). The developed model is described in words as well as being shown graphically.

ISM was described by Waller (1983) as being context free since it can be used in any complex circumstances whatever the content of those particular circumstances may be so long as it possible to identify a set of elements and a suitable contextual relation. Researchers have used ISM to come to an understanding of direct and indirect relationships among various variables across a range of industries. ISM is able to find a solution to complex issues by allowing the person using it to focus on only two ideas at a time. ISM analysis details are discussed in Chapter 6.

4.6.1.2 Analytical Network Process (ANP)

This research uses an AHP/ANP approach. The use of AHP/ANP is not restricted to a particular size of business but has been widely used in support of decision making in SMEs. As well as having a sound record in industry, the method of AHP/ANP is more

appropriate in relation to the nature of the proposed models than other techniques. For example, the proposed supplier selection method involves tangible and intangible criteria, which require measurements that have the following functionalities: to provide a realistic description of the problem, to structure the decision-making process, to incorporate both quantitative and qualitative factors, to express the relative importance of factors, to analyse alternatives, to support group decision-making and to allow the decision makers to focus on each small aspect of the problem. The AHP/ANP approach satisfies all these requirement described above.

The AHP approach was developed by Saaty, and is a decision-making method for prioritising (Saaty, 2001; 2004); the AHP has been used to prioritise marketing mix and other operational decisions since the 1980s (Saaty, 1982, 1986; Dyer and Forman, 1989).

As well as the importance of the criteria determining the importance of the alternatives in a hierarchical manner, it is the importance of the alternatives themselves that determines the importance of the criteria. In effect ANP is an extension of AHP to be used to deal with problems with dependence and feedback, providing a general framework through which decisions can be dealt with, with no assumptions being made in relation to the independence of higher level elements from lower level elements nor about the independence of the elements within a level as in a hierarchy (Saaty, 2004).

Understanding decisions mathematically in the discrete form of the spread of influence has more meaning than understanding them as continuous processes, although to some extent it is easier to develop the necessary continuous mathematics as a generalisation of the separate case. In addition, when dependence and feedback are included and their influence cycled with the supermatrix, ANP proves to be more objective and is more likely to reflect what happens in the real world. It is able to do things that the mind cannot do in a precise and thorough way. By considering these two observations together, it seems as though ANP should provide a better decision making tool than AHP. However, more work must be done when using ANP to capture the facts and the interactions because the procedure is a complex one.

4.6.2 Case Study

A case study is an in-depth study of a single example of whatever it is that the researcher wants to investigate. According to Ormrod and Leedy (2010) a case study consists of an in-depth study over a defined period of time of a particular individual, program or event. Depending upon the situation, the researcher is able to focus on either a single case or else two or more cases. They also make the point that a case study is of particular use to understand more about a situation about which little is known or which is inadequately understood. It also provides a useful way of either providing initial support or generating support for hypotheses.

A case study was decided upon as one of the methods for this research and in this case study use was made of the structured interview which consists of a standardised set of questions. A case study is not a survey, the reliability of which is crucially reliant on the instruments for the collection of data. In a case study it is the trustworthiness of a human instrument that is relied upon, that is the researcher, rather than techniques for the collection of data.

A case study is "an empirical inquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used" (Yin, 2003).

A case study is an empirical method of analysis resulting in a research report and it allows the use of a combination of methods as well as being flexible. It is considered to be a useful method of case research where the matter under investigation is both broadly based and complex (Dube and Pare, 2003). It is made use of in a number of disciplines, such as psychology, sociology or political science, but increasingly it is used to deal with problems in such areas as business and organisation. This is because in business, social phenomena are relevant and must also be studied (Yin, 2003). Lee (1989) defines an organisational case study as "An intensive study of a single case where the case consists of individuals, groups, and social structure in the setting of an organisation". It is generally held that the case study approach is useful to investigate the social phenomena involved in the network related risks to VO collaboration.

Case studies are considered to be an adequate method for the evaluation of the effectiveness of any action in a situation where quantitative studies are unable to

provide enough insight or explanation for coherences (Haas and Noster, 2007). For this reason case studies are used for a small number of cases, the reason for undertaking a case study being not to provide results that are statistically representative, but to provide deep insights and understanding in relation to a specific context that is often a social one. Although there are a significant number of cases where the findings could be more robust (Rowley, 2002), there are a small number of cases where the use of case study as a method enables the researcher to uncover material that is richer and more intimate (Halinen and Toernroos, 2005) and this is the reason why a single case study has been made use of for this research.

The evaluation of case studies when they are used as a research method for empirical work must be considered, though in the case of this research more quantitative methods, for example a questionnaire, have been used to prepare the ground for the case study. A number of approaches that can be employed when undertaking case study research have been evaluated and the use of this approach in this particular research is both explained and justified. The research design itself is then examined and the aims of the PhD explained, setting out the stages in the process and identifying some of the issues that were met with.

Although a case study appears simple, this is deceptive, and the researcher needs to be familiar with existing theoretical knowledge relating to the field of inquiry and must also have the skill to be able to differentiate significant variables from insignificant ones (Duggal et al., 2001). An unbiased approach is an absolute necessity.

The purpose of a case study is “to tell a big story through the lens of a small case” (Tan, 2004). Case studies are undertaken to focus on what is typical and this then leads on to meaningful generalisation and scientific abstraction which would be prevented by uniqueness (Majumdar and Gupta, 2001). The case study method is suitable for those situations where the phenomena as well as the context in which they occur are difficult to prise apart.

The selection of a case study was made in order to identify the strength of relationships in the ISM model and to find the probability of the occurrence of the sources of risks. In addition it validated the contribution for the research which had been identified through the previous questionnaires. The case study was conducted through discussion with Control 2K Limited.

Eisenhardt (1989) maintained that the case study "is a research study which focuses on understanding the dynamics present within single settings", and it has a long and influential history in the field of business research.

Table (4-3) shows the strengths and the weaknesses of case studies as summarised by Eisenhardt.

Table 4-3 Strengths and Weaknesses of Case Study (Eisenhardt, 1989)

Although accepting the potential weaknesses of the case study model, its strengths were compatible with being used to examine the research question. The research is appropriate for case study methodologies because "the focus is on a contemporary phenomenon within some real-life context" (Yin, 1994). Making a similar point Mitchell (1983) states that by choosing to undertake a case study, the researcher has acknowledged the potential that the case study has to illustrate a particular theoretical principle.

Also the use of a qualitative case study methodology has been supported by the empirical work that has been done and Yin (1994) suggests the use of a case study in circumstances where the researcher specifically needs to deal with context.

Eisenhardt (1989), when examining the approach taken in a number of research studies that have used this method, concludes that the combination of methods that are used, including historical records, internal documents, quantitative analysis, interviews and observations, constitutes the strength of this approach with the validity of the findings being underpinned by corroboration and triangulation.

Today, rather than being seen as an a preparatory undertaking to quantitative studies that have limited value in their own right, case studies are considered to be a valid form of enquiry (Sarantakos, 1998; Robson, 2002). Their validity is particularly

justified in a situation where the context of the research is too complicated for survey studies or experimental approaches, but where the researcher wishes to investigate the structure, processes and outcomes of a single unit (Sarantakos, 1998).

In real life situations it is not always possible to separate phenomenon and context, but the case study employs a set of technical characteristics, including data collection and data analysis strategies, which can be seen as its defining features.

The case study inquiry as defined by Yin (1994):

- Is able to cope with the technically distinctive situation which will have a number of variables proving of more interest than data points are able to, giving one result.
- Relies on many sources for evidence with data needing to come together as in triangulation, giving another result.
- The preparatory development of theoretical propositions to guide data collection and analysis which is beneficial to a case study.

Case studies can include both single and multiple cases although in some areas, multiple case studies have been considered to be a different "methodology" from single case studies. Yin (1994), however, considers that whether a case design is singular or multiple it falls within the same methodological framework; what is important is that every case should address a specific purpose within the overarching scope of the enquiry.

To summarise, the important points of case study research are that it is (Robson, 2002):

1. A strategy, i.e. a stance or approach, rather than a method, such as observation or interview.
2. Concerned with research, in a broad sense and including, for example, evaluation.
3. Empirical in that it relies on the collection of evidence in relation to what is happening.
4. About the particular: a study of that specific case.

5. Focused on a phenomenon in context, typically in situations where the boundary between the phenomenon and its context is not clear.
6. Undertaken using multiple methods of evidence or data collection.

The points listed above support the view that case study is very appropriate for research into the risks in VOs.

4.7 Validity and Reliability

According to Saunders et al. (2009) "validity and reliability of the data collected, enables the researcher to obtain some assessment of the questions".

Whatever method is chosen to collect data, it must be examined to establish the extent of its reliability and validity, reliability being the degree to which a test will produce similar results under constant conditions on all occasions, so that, in the event of a question eliciting different responses on different occasions, it can be regarded as not being reliable.

Validity is defined as whether an element does in fact measure or describe what it is supposed to measure or describe. It follows, therefore, that an element or a procedure could be reliable but not valid if, for example, it elicited the same response on all occasions but it was not measuring what it was supposed to be measuring. However, if a procedure is unreliable, it is also not valid.

4.7.1 Methods of Achieving Validity and Reliability

The aim of this research is to provide data that is both reliable and valid. The relevant forms of validity for this study are construct and external validity (Ellram, 1996; Ghauri and Gronhaug, 2005; Yin, 2003). The method used for data collection is able to ensure construct validity, where multiple sources of evidence and chains of evidence are used (Yin, 2003). The chain of evidence is retained throughout the research and the research questions are reflected in the questionnaires, case study, the interview questions and the conclusions where the validity of the research has been increased by the use of the triangulation method. In order to follow this method information was gleaned from different sources and used to back the theories for the research (Leedy and Ormrod, 2010), with a qualitative case study being undertaken to assess how well the VO risk management contribution can be applied in practice.

External validity, referring to generalisibility (Ellram, 1996; Ghauri and Gronhaug, 2005; Yin, 2003) is achieved through the links to the theories related to risk in VOs in the literature.

Different methods have been used to increase the reliability for this research. These are:

1. Critique of the sources undertaken, which means evaluating the trustworthiness of the sources (Leedy and Ormrod, 2010).
2. The following of a consistent procedure throughout the duration of the research (Ellram, 1996; Yin, 2003).

4.8 Conclusion

The following is a summary for the methodology-data collection:

- Literature review to support problem definition.
- Quantitative and qualitative methods have been used for this study so a balanced check could be developed using four phases:
    1. Identification of risk sources in virtual organisation collaboration through the use of the literature review and a questionnaire to collect the opinions of experts.
    2. A questionnaire survey to collect information for ISM.
    3. A questionnaire survey to collect information for ANP.
    4. Data collected from interview that was based on case study.

This chapter has provided an overview of research methods used in the study. A range of methods was considered to be the most suitable approach to the collection and analysis of the data relevant to this research. An analysis of the underlying debates was undertaken in order to justify the methods that were selected. In order to utilise the positive aspects of both qualitative and quantitative research approaches, methods were selected that included the use of a questionnaire and a case study, and the use of Warfield's ISM and Saaty's ANP.

It should be realised that for any research the choice of a methodology that is best suited to the aims of the research is of critical importance. However, at the same time, concerns relating to the methodological 'purity' of the research should not be allowed

to overshadow its aims. After describing the principles of the research and emphasising the importance of logical design appropriate for the explicit purpose of the research, this chapter has proceeded to give an explanation of the provenance of the research question that the research addresses. The methodology that has been used for this thesis includes an extensive literature review that has been dealt with in an earlier chapter and also employs the use of a set questionnaire and a case study. A variety of tools have been used, employing both quantitative and qualitative data collection and analysis.

A summary about the SYNERGY project has also been included in this chapter because of the importance of acknowledging the relation between this research and a European funded project which demonstrates the significance of the research.

Chapter 5 Risk Sources Identification in Virtual Organisation

5.1 Introduction

While there are many advantages attaching to the use of virtual organisations there are also a number of challenges, including risks, that have become apparent through undertaking a review of the literature. In total 13 sources of risk were found stemming from the network related risks of the VO where the emphasis of the study was placed and these included lack of trust between partners, possible lack of commitment from top management, inadequate information sharing and collaboration agreements, differences in ontology, lack of heterogeneity, issues with structure and design, loss of communication between partners, cultural differences, problems relating to geographical distribution, knowledge of risk, problems associated with bidding for several VOs simultaneously and the selection of the wrong partner/s. This chapter is a comprehensive study identifying these threats to gain a better understanding by going through them one by one using the literature and previous studies, then evaluating and ranking these sources based on a survey study.

This chapter is further organised as follows. The first section is an introduction. The second section categorises the risks followed by a discussion of risk sources identification at VO network level. The fourth section discusses the questionnaire survey, validation and results of the survey, and the chapter ends with a conclusion.

5.2 Risk Categorisation

Collaboration with other enterprises is vital if businesses are to meet their business objectives. Doing business worldwide has become crucial to the survival of some enterprises while for others the vital element is focusing locally. It is necessary for all enterprises, whatever their size, to come to corporate agreements with other enterprises and this is particularly important for Small and Medium sized Enterprises (SMEs) who in order to increase their own added value need to operate together with others within the market. In today's market, whether or not an enterprise is successful will often be largely dependent upon whether it is able to inter-operate smoothly with others.

The environment within which SME's have to function in the 21 century is one that is increasingly competitive and dynamic and therefore, simply to cope in such a situation, SMEs have to seek for a number of methods to employ and one of these is to group together within a VO. It is, however, not easy to become part of a VO and there are risks to be dealt with throughout the whole process from the initial formation of such a group through to the point where it dissolves. In order that the challenges can be met successfully, it is important that enterprises should be helped to both recognise the risks and then surmount them.

Collaboration is necessary in order for enterprises to compete and it is also necessary for them to operate with as much speed and flexibility as possible so that ideas and proposals can become initiatives with the capacity to generate new revenue.

As is the case in the supply chain, the risks associated with VO have different sources and Jüttner et al. (2003) have suggested that the sources of risk as they affect the supply chains should be categorised into three areas these being, risks external to the supply chain, risks internal to the supply chain and those that are network related. Such risks as natural risks, political and social risks and risks connected to the industry market; these would be categorised as external risks while internal risk sources are likely to be associated with labour problems such as strikes, or production problems such as machine failure, as well as problems with IT systems and network related risks stemming from the relationships within the supply chain, which has also been cited by Blackhurst et al. (2004) as a risk that is different in kind but that has a direct relationship with collaboration.

Gaudenzi and Borghesi (2006) have pointed to two more aspects of risk that should be considered when risk is being assessed. These aspects exist at a number of levels within the supply chain, within the enterprise itself and at the network level. In this area the evaluation of risk will be intrinsically subjective with each analyst relying on his/her own theories of what the risk is and what is happening either side of the area of risk.

While the risk sources that are internal or external are essentially similar, the network related risks have a different source as a result of the different relations between the supply chain and the virtual organisation partners. Those network risks that relate to any collaboration do not depend solely on the enterprise goals and objectives. A

dyadic type of assessment is necessary as a result of the sharing of responsibilities and the changing nature of the relationships involved if these situations are to be actively managed in relation to network related risks, since the identification of risk becomes more complex as a result of the interdependency of enterprises (Hallikas et al., 2004).

Furthermore, within each individual organisation making up a VO there will be a particular philosophy and particular goals but, at the same time, it is crucial that all partners should have common aims in relation to the ultimate market as well as taking account of the relationships with other members (Mentzer et al., 2001).

5.3 Identification of Risk Sources in the Virtual Organisation

A number of authors who have researched and written about this area have identified where risk arises in VOs. Thorough examination of the literature identified 13 sources of risk and impediments which can be possible causes of failure to hit targets in the areas of delivery time and cost and quality and which, in some instances, have caused the collaboration to collapse completely. A discussion of each of these sources of risk follows.

These risk sources have been selected from the literature after going through 61 journal papers from 45 different journals which have been published during the period 1994 till 2008, 7 papers which have been published in connection with several conferences during the period 1995-2006, 3 chapters from books published during 1997-2007 and one guide for managers published in 2003. Table (5-1) summarise the risk sources and their references in the literature.

Risk sources	**References**
1. Lack of trust between partners	Sahay and Maini, 2003; Mistry, 2005; Sinha et al., 2004; Lengnick-Hall 1998; Chiles and Mcmackin, 1996; Spekman and Daivs, 2004; Camarinha-Matos and Afsarmanesh, 2007; Lewickli et al., 2006; Grover ,2005; Panteli and Sockalingham, 2005; Twomey, 1995; Pascale, 1994;Das and Teng, 2001; Bachman, 2001; Luhman, 1979; Ryutov et al. ,2007; Lewicki et al., 1998; Zaheer et al.,1998.
2. Inadequate collaboration agreement	Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bullinger 2003; You and Yu, 2006; Quicrchmayr et al., 2002; Mentzer et al., 2001; Narayanan and Raman, 2004; Tsay, 1999; Chauhan and Proth, 2005; Panteli and Sockalingamb, 2005; Zheng et al., 1998; Chiles and

	Mcmakin, 1996.
3. Heterogeneity of partners	Camarinha-Matos and Afsarmanesh, 2007; Sari et al., 2007; Singh and Kant, 2008; Jung et al., 2005; Jung, 2008; Hull, 1997; Menczer, 2004.
4. Ontology differences	Gruber, 1995; Plisson et al., 2007; Camarinha-Matos, 2002.
5. Structure and design	Grabowski and Roberts, 1998; Panteli and Sockalingam, 2005; Zhang and Dilts, 2004; Camarinha-Matos and Afsarmanesh, 2007; Finch, 2004; Bandyopadhyay et al., 1999.
6. Loss of communication between partners	Grabowski and Roberts 1998; David and Malone, 1992; Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bamford, 2004; Bullinger, 2003; Gunasekaran et al., 2008; Spekman and Davis, 2004.
7. Culture differences	Grabowski and Roberts, 1998; Chen and Feng, 2002; Prefontain, 2003; Camarinha-Matos and Afsarmanesh; 2007; Singh and Kant, 2008; Lemken et al., 2000; Chase,1997; Alawi et al., 2007; Gunasekaran et al., 2008; You et al., 2006 ;Crossman and Kelley, 2004.
8. Bidding for several Virtual Organisations at the same time	Camarinha-Matos, 2002; Nguyen et al., 2005; Prefontaine, 2003; Babanova et al., 2003; Hoogendoorn and Jonker, 2006; Szirbik et al., 1999.
9. Lack of information sharing	You et al., 2006; Childerhouse et al., 2003; Zhenxin et al., 2001; Yu et al., 2001; Lee, 2002;Lee et al., 1997; Zeng and Pathak, 2003; Koh and Nam, 2005; Rahman, 2004.
10. Lack of top management commitment	Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bamford, 2004; Bullinger, 2003; Kanter, 1997; Brand, 1998; Chong and Choi, 2005; Goll et al., 2007; Spekman and Davis, 2004.
11. Lack of Knowledge about risks	Hallikas et al., 2004; Harland et al., 2003; Chopra and Sodhi, 2004; Jüttner, 2005; Sinha et al., 2004; Shtub et al., 1994; Norrman and Jansson, 2004.
12. Wrong partner/s selection	Sari et al., 2007; Grabowiski and Roberts, 1998; Chen and Feng, 2002; Spekman and Davis, 2003; Prefontaine, 2003; Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bamford, 2004; Bullinger, 2003; Wilmot and Hocker, 2001; Amson et al., 1995; Pelled et al., 1999; Jehn and Mannix, 2001.
13. Geographic location	Prater et al., 2001; Ritchie and Brindley, 2002; Dewitt et al., 2006; Porter, 1998; Grabowski and Roberts, 1998; Chen and Feng, 2002.

Table 5-1 Risk Sources and their References in the Literature.

The sources of risk are discussed as follows.

5.3.1 Lack of Trust between Partners

This was the most frequently occurring VO risk source discussed in the literature. The amount of trust that exists between partners relates to how much partners believe in the honesty, generosity and overall competence of the others. Where there is no trust between partners problems arise; for instance they become unwilling to pass on sensitive information and find it difficult to agree about how finances should be managed. In short they do not work to promote VO collaboration.

Trust and commitment are crucial to collaboration and for cooperation over a period of time together with a preparedness to share risks (Sahay and Maini, 2002). The more the trust between partners, the more the commitment (Mistry, 2005). However a lack of trust is one of the main contributors to supply chain risks (Sinha et al., 2004).

According to Lengnick-Hall (1998) where trust has grown out of good communication, it leads to resources that themselves can give a competitive edge. Trust assumes that those party to an agreement will not act opportunistically even when they are tempted by possible short-term advantage to themselves (Chiles and Mcmackin, 1996), and this can make a marked contribution to the stability of an organisation in the long term and to its network (Spekman and Daivs, 2004).

According to Camarinha-Matos and Afsarnmaesh (2007) it is necessary for trust to be established between members in a Virtual Organisation Breeding Environment (VBE) if there is to be efficient cooperation. Where an analysis of trust in the organisation indicated that this was likely to be the main impediment for the VO, an objective trust analysis approach to the VBE was undertaken in order to identify and describe the source of trust and the way that the various values of trust criteria impacted on the levels of trust together with the influences that they exerted upon the different criteria for trust.

According to Lewicki et al. (2006), most studies of trust undertaken for organisations place emphasis on subjective trust sources relying on recommendation, their ranking, or their reputation, with relatively few looking closely at objective trust sources (Grover, 2005) for their reviews of the past performance and the current position of an

organisation in order to assess the degree of trustworthiness. These two approaches together, that is the assessment of both subjective and objective trust, are able to define the trust and the trust relationships and also establish a basis to measure and assess the level of trust within an organisation.

For collaboration to work all partners must work together to solve problems and this demands that there is powerful mutual trust and the commitment to expend time and effort (Camarinha-Matos and Afsarmanesh, 2007). Where risk arises from the VO being exposed to partners' opportunistic behaviour, or else to any uncertainty and ambiguity or only partial information, trust becomes vital in order to reduce it. However trust itself invites risk since it exposes those who trust to the opportunistic behaviour of others (Panteli and Sockalingham, 2005). There is an important constructive relationship between trust and conflict resolution in any inter-organisational arrangement (Twomey, 1995) and trust enables benefit to be gained from conflict since conflict can often lead to innovation (Pascale, 1994).

Risk as it exists in inter-organisational collaborations has been considered by Das and Teng (2001) through the examination of two types of risk occurring in strategic alliances, that is relational risk and performance risk, and specifically through examining the relationship between trust and risk. Trust itself brings with it risk since there is always the possibility that the trust will be betrayed; this risk can be addressed by the use of sanctions and legal provisions even if these will never be called into use (Bachman, 2001; Luhman, 1979).

Ryutov et al. (2007) consider that the establishment of trust between VO collaborators is essential to successful joint performance and present a conceptual framework dealing with key concepts that will initiate trust between VO collaborators in on-demand VO. Lewicki et al. (1998); Zaheer et al.(1998) argue that without trust it is not possible for there to be social, economic or political dealings since one party must initiate the contact making the unspoken assumption that there is likely to be a positive response from the other party.

5.3.2 Inadequate Collaboration Agreement

A lack of clarity in the agreement into which partners enter is one of the circumstances that can lead to insufficient collaboration. According to (Camarinha-

Matos and Afsarmanesh, 2007; Westphal et al., 2007; Bullinger, 2003) where any definition dealing with objectives is weak, together with the strategies and basic conditions, and where expectations are poorly managed, and contracts perceived as inadequate or unfair, there may well be risk of failure.

The moral risk before the VO is set up has been discussed by You et al. (2006), since at that point members may be able to reduce the extent of knowledge sharing though setting up a contract, with Quirchmayr et al. (2002) describing contracts for negotiation where a legally binding contract may have to be signed by each partner requiring them to accept the process, protocols, and constitution of the VO.

Both risks and rewards must be shared among supply chain members according to Mentzer (2001) if supply chain management is to work efficiently since all members must respond to the same incentives which results in a fair distribution across the network of the risks as well as the costs and rewards of the business (Narayanan and Raman, 2004). Tsay (1999) describes the sharing of revenue as a type of supply chain contract that facilitates the sharing of risks also. A model for a provider retailer partnership based on shared profits was discussed by Chauhan and Proth (2005). Panteli and Sockalingam (2005) considered the issues of trust and conflict as they exist within virtual inter-organisational agreements as being the intrinsic issues present in any organisational agreement.

The degree of risk and benefit sharing differs with the type of the collaboration. Joint ownership is often the mechanism with risks arising from joint venture or strategic alliance (Zheng et al., 1998). Methods of incentive for the collaborating parties may be through the use of obligation contracting, schemes for profit sharing and shared property rights as well as ownership control.

Where collaborations are not so formal the nature of sharing risks and benefits may not be so clear, therefore lasting commitment may depend on agreements being made so that sensitive information, knowledge and competencies can be shared. Where there is trust there will be less reluctance to share sensitive information since the perception of risk is reduced. This in turns means that complex contracts are less likely to be seen as necessary to protect interests and there is trust in the decision making across the group since it is believed that all perspectives will be considered (Chiles and Mcmakin, 1996).

5.3.3 Heterogeneity of Partners

Heterogeneity means the differences that exist between partners in terms of incompatible hardware and operating systems, differences in language and the recording of data, and in the meaning of the terms that are used.

(Camarinha-Matos and Afsarmanesh, 2007; Sari et al., 2007) have all referred to this heterogeneity between possible partners as it exists in information technology infrastructures, working methods and business practice, as a possible obstacle to the VO operation.

Where there is poor technological infrastructure this makes it difficult to put in place knowledge management (Singh and Kant, 2008). Jung (2008) saw variations between these categories as an impediment to the progress of efficient cooperation since the semantics of the information from various entities may differ. These variations occur because of the variations in terminology with a number of synonyms and antonyms in use but also and more importantly because of differences within the databases derived from the knowledge structures (Hull, 1997) and the ontology (Jung et al., 2005).

Where businesses are based on taxonomy, two important semantic heterogeneities are involved, that is one based on language and another on structure. In terms of lexical differences, although there may be a semantic correspondence between the classes of taxonomies, certain keywords may differ where they are used for expressing classes between VOs (Menczer, 2004), whereas the semantic differences such as the descriptions of sub-class, super class etc between two taxonomic models varies (Jung et al. , 2005).

5.3.4 Ontology Differences

Ontology is a philosophical system that is concerned with the nature of being. Gruber (1995) defines ontology as “a formal, explicit specification of a shared conceptualisation”. Problems in this area of ontology crop up when there are two different words with the same meaning or even where one word means different things as it is used by different partners.

According to Plisson et al. (2007) ontologies can be said to offer an economical and unambiguous way of representing knowledge so that it can be jointly understood and

therefore provide a basis for sharing. However, before terminology can be shared, there needs to be consensus between partners as to which terms they will use when collaborating if problems have previously arisen because ontologies have not been held in common between organisations working together (Camarinha-Matos, 2002).

What ontology can do is provide a means of sharing knowledge where there is an understanding of concepts and relationships within a certain area and communication between those involved in this area where the fundamental ontology is one acting as a glossary for a limited vocabulary which are the agreed terms used within a specific area. Where problems occur as a result of differing ontologies there may be disagreements in relation to both the formation and the processes of collaboration which will add to the risks in the VO.

5.3.5 Structure and Design

An important characteristic of a VO is where reconfigurable structures exist in relation to settings that are more conventional (Grabowski and Roberts, 1998) and this can manifest itself through a variety of forms and structures such as greater permanence, interactivity, greater complexity or being knowledge intensive (Panteli and Sockalingam, 2005).

VO's dynamic structure creates problems since it is not possible to co-ordinate comparable activities because responsibilities are not adequately shared out and it may not be clear what the tasks and the rules are nor who is in overall charge, nor how far any control extends, and where a phase leader is unable to manage the other partners and does not have the right to make decisions the whole network is affected. Elements of structure and design include central planning or decentralisation, the extent of any specific control and specialisation and how labour is divided (Zhang and Dilts, 2004).

According to Camarinha-Matos and Afsarmanesh (2007) where the infrastructure does not offer the opportunity for joint collaboration, this proves an obstacle to a VO. Control that is weak or ineffective can occur outside the project and can spring from inter-organisational networking in a way that resembles that where, according to (Finch, 2004; Bandyopadhyay, et al., 1999) control over suppliers and customers was weak within the grouping leading to possible risk.

5.3.6 Loss of Communication between Partners

The variation inherent in VO and the changes in structure can lead to less communication and here an inverse relationship comes into play since the less the communication the more the uncertainty.

According to Grabowski and Roberts (1998) while communication is fundamental to any organisation it is of even more vital importance within VOs. Any communication in a virtual form must respond to specific customer demand with speed (David and Malone, 1992). Others (Camarinha-Matos and Afsarmanesh, 2007; Westphal et al., 2007; Bamford et al., 2004; Bullinger, 2003; Gunasekaran et al., 2008) have all seen failing communication as an obstacle within VOs and where this happens, failure could follow.

It is likely that a more trusting relationship between collaborators will be the result of better communication; the crucial aspect is to go beyond technology to establish trust in relation to key issues with a free flow of information and where the most critical issues can be raised with the partners being at ease even when exchanging sensitive information. Partners must understand that communication has to be about commitment levels rather than about technology (Spekman and Davis, 2004).

5.3.7 Culture Differences

There may be several cultures within a VO and this may lead to lack of alignment between processes and inaccurate communication, impacting on the sharing of information (Grabowski and Roberts, 1998; Chen and Feng, 2002; Prefontaine, 2003; Camarinha-Matos and Afsarmanesh; 2007).

The fundamental values and beliefs of any culture, together with value norms and the customs underpinning the behaviour of people within an organisation, define it (Singh and Kant, 2008; Lemken et al., 2000). However, where there is no over-arching culture in any organisation this has a negative impact on the successful management of knowledge (Chase, 1997). It should also be taken into consideration that culture is concerned with many aspects but mainly with collaboration and trust. Where trust exists within a culture that is open to knowledge, it will enhance the relationship between both groups and individuals and as a result the sharing of knowledge will become positive and open (Alawi at al., 2007). Where there is either no collaboration

or else a very low level, this will inhibit the exchange of knowledge between individuals as well as the group (Gunasekaran et al., 2008).

You et al. (2006) focus on members of a VO, saying the centre of any enterprise resides in its values and they therefore use such terms as staff value, faith and behaviour in relation to this so that when those joining a VO undertaking come from different enterprises shared knowledge will be in short supply. It may be that those who come together to form a VO are culturally dissimilar and they may never before have worked in a partnership and so they will have little experience in common. This is an important issue since enterprises have become increasingly transactional and virtual partnerships have been made easier by technological advance, and this brings with it different cultural backgrounds and different uses of language as well as values, all of which impact on the dispersed team function (Crossman and Kelley, 2004).

5.3.8 Bidding for Several Virtual Organisations at the Same Time

Some partners may choose to be active in several VOs simultaneously when they do not have the capacity to cope with this. Risk then occurs when one partner wins two or more VO bids and his capacity as a partner, either in terms of resources or staff, is not sufficient to undertake the tasks involved in more than one VO. Although this risk occurs, there is as yet little discussion of it in the literature and it has not been much researched.

Even in Camarinha-Matos (2002) the vagueness is there when he discusses only the other causes of risk in a VO. Nguyen et al. (2006) discuss only resource management and bidding strategies as possibly problematic in a VO whereas Prefontaine (2003) has mentioned the lack of consensus or involvement.

The problems that an agent may face associated with bidding requests where a commitment of resources must be made have been studied by Babanov at al. (2003). It can be the case that there can be more problems related to the formation of a VO than the tasks that have to be undertaken in the VO itself, since there may be unknown constraints and profiles existing within an environment that is inherently dynamic (Hoogendoorn and Jonker, 2006; Szirbik et al., 1999).

5.3.9 Lack of Information Sharing between Partners

It is vital for information to be shared in the VO due to its dynamic nature and its intention to take advantage from the market quickly; if sharing of information is inadequate there will be a risk to the collaboration. However, the availability of more information sharing can cause loss of Intellectual Property Right (IPR).

In order for knowledge sharing to be accepted, a VO must have established values relating to sharing and collaboration as part of their fundamental ethos. Some may feel that they have an advantage because they possess knowledge that others do not and this causes a refusal to share knowledge with others out of a desire to protect their own interests (You et al., 2006).

Networks must share information because where it is lacking the result may be panic, confused behaviour and increased costs (Childerhouse et al., 2003). It is agreed currently by models for supply chain management that sharing business information is vital, connecting supply chains completely together (Zhenxin et al., 2001; Yu et al., 2001). Where the free exchange of information runs throughout the whole of the collaboration, starting with the stage of product development, through the operation right on until the end of life stage of the product's cycle, it has been seen to be very effective in bringing about a reduction in those risks that are associated with inventories, becoming obsolete and supplier failure (Lee et al., 1997; Lee, 2002). When the internet and e-commerce began to be used, it gave the opportunity for all those concerned with an SC to exchange information in real time, giving a global reach and minimising the costs of transactions (Zeng and Pathak, 2003) the result of which was a significant fall in costs associated with distribution and coordination (Koh and Nam, 2005).

According to Rahman (2004) it is felt that there is a risk involved in sharing with other members such sensitive information as inventory levels and production schedules. Information sharing should be subject to choosing those with whom the information will be shared, what type of information it will be and of what quality.

Efficient network coordination depends upon information sharing, with a number of studies finding that it impacts significantly on network performance and, in particular, is able to reduce the bullwhip effect. Information sharing leads to better operational

decision making within enterprises which leads to more efficient use of resources and lower costs (Lee et al., 1997; Yu et al., 2001).

However, the situation may arise where not all enterprises wish to share information relating to their details with all their partners, believing that such sharing may give their competitors an advantage. Therefore, enterprises thinking in this way may make available only aggregated data on the category level of products without providing the depth of detail that is necessary.

5.3.10 Lack of Top Management Commitment

Risk is increased where a weak part is played by top level management at particular points in VO formation or in operations where crucial decisions are made (Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bamford et al., 2004; Bullinger, 2003).

According to Kanter (1997) there is a risk that low commitment to a partnership will lead to a failure to meet objectives. The role of top management is critical with it being responsible for all activities at every level of an organisation, for the technological infrastructure and for decision making in order that there will be efficient creation of knowledge together with sharing and use of it (Brand, 1998). Where there is limited top management commitment to a partnership the risk exists that there will be a failure to meet objectives in particular in relation to the creation and sharing of knowledge (Chong and Choi, 2005). Such knowledge makes it possible to identify strengths and weaknesses within an organisation as well as providing an analysis of any threats or opportunities that may exist in the external environment (Goll at al., 2007).

All partners must be treated fairly, in the sharing of risks as well as rewards, and there should be an effort to develop this sense of shared commitment as far as it will extend. However, there should be mutual agreement in relation to network vision and a recognition that control has a basis in contract which provides a limit to commitment and trust (Spekman and Davis, 2004).

5.3.11 Lack of Knowledge about Risks

Where there is no knowledge of the risks that may occur there is an increased likelihood that these risks will occur and also have a greater impact.

According to Hallikas et al. (2004) where there is a greater understanding of the risks that may occur in a supply chain there is likely to be improved decision making and lower risk to each enterprise involved as well as to the whole undertaking. It is possible to categorise the many different forms of supply chain risks in terms of how their occurrence would affect a business and its environment (Harland et al., 2003). With an understanding of the range of supply chain risks and how they interact can come a response from the enterprise creating balanced and efficient risk reduction strategies (Chopra and Sodhi, 2004). It is important for organisations to come collectively to an understanding of the risks they may face (Jüttner, 2005).

Risk analysis offers a means to detect risk in a process (Sinha et al., 2004) and this enables a secure environment in which decisions can be taken so that there is a continuous assessment of the possibility of risk; it is possible to decide which are serious and then take appropriate action to deal with them (Shtub et al., 1994). In order to determine the exposure of a supply chain to risks, it is necessary for an enterprise not only to identify those risks that directly threaten its operations but also the potential for risk from any causes or sources at every significant stage of the supply chain (Norrman and Jansson, 2004).

5.3.12 Wrong Partner/s Selection

According to (Camarinha-Matos and Afsarmanesh, 2007; Westphall et al., 2007; Bamford et al., 2004; Bullinger, 2003) such things as objectives, strategies, core competencies and capabilities that are irreconcilable cannot be complementary.

While Sari et al. (2007) consider insufficient information about partners to be an obstacle to the VO selection others, including (Grabowiski and Roberts (1998); Chen and Feng (2002)), think that a range of interests increases the risks to a VO.

It is important that enterprises concentrate on those relationships that develop between partners to ensure that their foundation is mutual trust, commitment and belief in capabilities. These are the elements that keep a partnership together as opposed to a

situation where a partner that has been a poor choice is unwilling to share information that is vital to the success of the SC and may even make no effort to contribute to the success of the chain (Spekman and Davis, 2004).

According to Prefontaine (2003) where an unsuitable partner is chosen this constitutes one of the risks to the collaboration. Wilmot and Hocker (2001) explained that conflict can be as the manifestation of a struggle between a minimum of two parties who are mutually dependant but who have divergent goals, with limited rewards, and who have other parties placing obstacles in the way of the achievement of their goals. Organisational conflict manifests itself through conflicting relationships or affective conflict, cognitive or task conflict, and conflict over process.

It is therefore the case that conflict has the capacity to bring about divisions, to diminish trust and weaken relationships which limits open communication and the value that the creation of knowledge can add (Amason et al., 1995).

Task conflict is generally concerned with tasks and arises from differences of judgment as to which is the best solution to use to achieve the organisation's objectives. It is a situation in which there is disagreement about issues to do with tasks, including goals, which action should be taken, and other key areas for decisions (Pelled at al., 1999).

Conflict over process relates to an awareness of disagreement about aspects of how a task should be undertaken. Conflict in this area arises from differences of opinion relating to roles and responsibilities, as well as to time schedules and source requirements (Jehn and Mannix, 2001).

5.3.13 Geographic Location

Risk may be increased by geographic locations with there being a direct correlation between distance and risk. Some locations throw up more problems because of, for instance, political and legal difficulties (Ritchie and Brindley, 2002; Dewitt et al., 2006). Prater et al. (2001) looked at the size of any geographic area that a network covered, what political areas it encompassed and which borders were crossed, considering these all to be elements contributing to the partners' exposure to risk.

Porter (1998) observed that geographic distance gives rise to complications and to an increase in logistic cost. Also Grabowski and Roberts (1998), Chen and Feng (2002) considered that there was increased risk as a result of geographic distance.

5.4 Questionnaire Survey

In this chapter a questionnaire based survey has been used to achieve the third objective of this research. The risk sources have been evaluated based on experts' judgment through a qualitative questionnaire sent to experts in the field. This approach, rather than a wider survey of VO participants in general, was adopted because of the nature of the study which requires a deep understanding of the subject, as well as experience of a range of VO examples.

The email survey was used for the administration of the survey. Questionnaires, including cover letters were emailed to the selected respondents. The experts were selected from SYNERGY partners (see section 4.2). SYNERGY is a research project funded by the European Commission and the SYNERGY team is itself a virtual organisation of eight SMEs, universities and research institutes from six countries throughout Europe.

Out of a total of 16 questionnaires emailed only 9 questionnaires from experts from both academic and industrial backgrounds were returned back complete and usable for the SPSS analysis which has been used for getting results. This gives an effective response of 56%. The methodology and the respective results are separately discussed in the next two sections.

A structured questionnaire, running into six pages and having 27 questions, was framed to collect responses on a five-point Likert-scale to determine the significance of the risk source and a three-point Likert scale to determine confidence relating to the answer. On the five-point Likert-scale, 1 stands for very low and 5 for very high for the questions relating to the level of significance and on the three-point Likert-scale 1 stands for low and 3 for high for the answers relating to confidence. The questionnaire asked the respondents to indicate the level of risk source significance and their confidence about their answers. In order to study the hierarchical importance of these sources, Cronbach's coefficient (α) was calculated to test the reliability and internal consistency of the responses. The value of a Cronbach's coefficient of more than 0.5 is considered adequate for such exploratory work (Nunally, 1978). Using

SPSS the value of α in this study was found to be 0.97. It implies that there is a high degree of internal consistency in the responses to the questionnaire.

5.4.1 Validation of the Questionnaire

The questionnaire was tested for two types of validity:

- Content validity.
- Construct validity.

Content validity primarily depends on an appeal as to the appropriateness of content and the way it is presented (Nunally, 1978). The instrument developed in this study demonstrated the content validity as the selection of measurement items was based on both an exhaustive review of the literature and detailed evaluations by academics and industrialists. The construct validity was verified by factor analysis. Calculating using SPSS all the items in the question related to the risk sources have been found with a minimum factor loading of 0.72. This is in agreement with Kim and Mueller (1978) who suggested the use of only those items which have a factor loading of more than 0.40.

5.4.2 Results of the Questionnaire

A questionnaire survey, which investigates the risk sources in VO collaborations, has been used in this part of the research and the SPSS (Version 15.00) software have been used to analysis the results. The relevant description statistics are shown in tables (5-2 and 5-3). In table (5-4) risk sources are presented in decreasing orders of their significance. Table (5-3) represents the degree of confidence in the respondent's answers relating to the significance of each source.

Table 5-2 Survey results of sources significance

Risk Source	Minimum	Maximum	Mode
1. Lack of trust between partners	Medium	Very High	Very High
2. Inadequate collaboration agreement	Medium	Very High	High
3. Heterogeneity of partners	Low	Very High	High
4. Ontology differences	Medium	Very High	High
5. Structure and design	Low	Very High	Medium
6. Loss of communication	High	Very High	Very High
7. Culture differences	Low	Very High	Very High
8. Bidding for several VOs at the same time	Low	Very High	Medium
9. Lack of Information sharing	Low	Very High	Medium
10. Lack of top management commitment	Medium	Very High	High
11. Lack of knowledge about risks	Low	High	High
12. Wrong partner/s selection	Medium	Very High	High
13. Geographic location	Low	High	Medium, High

Table 5-3 Survey results of confidence about answers

Risk Source	Minimum	Maximum	Mode
1. Lack of trust between partners	Low	High	High
2. Inadequate collaboration agreement	Low	High	High
3. Heterogeneity of partners	Medium	High	Medium
4. Ontology differences	Medium	High	High
5. Structure and design	Medium	High	Medium, High
6. Loss of communication	Medium	High	High
7. Culture differences	Low	High	High
8. Bidding for several VOs at the same time	Low	High	High
9. Lack of information sharing	Low	High	High
10. Lack of top management commitment	Medium	High	Medium
11. Lack of knowledge about risks	Low	High	High
12. Wrong partner/s selection	Low	High	High
13. Geographic location	Low	High	Medium

Based on the literature review and previous studies the following risk sources are identified, which have potential impact on failure to meet delivery time, on cost and quality targets or on the total failure of the collaboration.
Table (5-4) summarises the questionnaire results as raw data.

Table 5-4 Risk Sources Rank

Risk Source	Importance	Confidence about answer	Rank
Lack of trust between partners	91%	93%	**1**
Loss of communication	89%	93%	**2**
Inadequate collaboration agreement	87%	89%	**3**
Lack of information sharing	82%	85%	**4**
Lack of top management commitment	82%	81%	**5**
Wrong partner/s selection	78%	85%	**6**
Ontology differences	73%	85%	**7**
Structure and design	73%	78%	**8**
Culture differences	71%	78%	**9**
Heterogeneity of partners	69%	89%	**10**
Geographic location	67%	81%	**11**
Lack of knowledge about risks	67%	67%	**12**
Bidding for several VOs at the same time	64%	78%	**13**

5.5 Conclusion

In this chapter a number of risk sources in the VO have been identified which may cause negative effects on time, cost, quality or even total failure for the collaboration, through a qualitative study using the results from the questionnaire. Experts have found from the sources that the most important risk factor is lack of trust which was the area receiving the most interest in the previous studies at the same level; loss of communication is not far behind lack of trust with the same confidence percentage relating to the answers from the experts. Inadequate collaboration agreement, lack of information sharing and top management commitment ranked in the second level of importance. In the third level of the table wrong partner/s selection, ontology differences, structure and design and culture differences are more important sources than the last four sources (heterogeneity of partners, geographic location, lack of knowledge about risks and bidding for several VOs at the same time) which ranked at

the bottom of the table. It can be seen that these four sources of risk are still sparsely covered in the literature and these sources did not receive much attention in the previous studies as they did not occur so much as the others in the literature and ranked in the fourth level as the least important sources.

These thirteen risk sources identified in this chapter have significant overlaps and relationships that are sometimes difficult to see. A more complete understanding of these risk sources and their relationships may be reached through logical structure such as Interpretive Structural Modeling (ISM). ISM is a well established methodology for identifying relationships among specific items which define a problem or an issue. The opinions from the group of experts mentioned above are used in developing the relationship matrix which was later used in the development of the ISM model. This will help partners to take better decision as to whether to join the VO or not. Even the relationships structure can be addressed using other approaches such as the Analytical Network Process (ANP), which requires a decision structure to help determine the strength of relationship and for decision making. Simulation and systems dynamics modeling may also be used to help identify how risk sources in VO will influence it and its performance results.

Chapter 6 Interpretive Structural Modeling (ISM)

6.1 Introduction

Any methodology for dealing with complex issues must be able to break complexity down into manageable chunks of information so that the human mind can deal with it. Interpretive Structural Modeling (ISM) tries to do this, by enabling an individual or a group to focus on the interrelations between two elements in an issue at a time, without losing sight of the properties of the whole.

ISM has been described by Warfield (1982) as "a computer-assisted learning process that enables an individual or a group user to develop a structure or a map showing interrelations among previously determined elements according to a selected contextual relationship". In addition Waller (1983) maintains that ISM is a system that transcends context enabling it to be used in any complex situation whatever the content of that situation might be so long as it is possible to identify a set of components and define a relevant contextual relation. These components may include qualitative and quantitative elements which means that it is possible to include more than simply measurements. This aspect means that ISM is a more flexible instrument than a number of other approaches to conventional quantitative modelling and it is able to provide a language for qualitative modelling in order to bring structure to complexity and enable a group of users or individual users to map their thinking in relation to an issue through the construction of an agreed structural model.

The aim of this chapter is to establish relationships between the elements of the risk sources and also classify these risks depending upon their driving and dependence power using the ISM methodology. This is a well-established methodology for identifying and summarising the relationships between specific items which define a problem or an issue (Sage, 1977; Warfield, 2005). A practical tool for SMEs to use is made available by this model to enable them to focus on those risks sources that must be addressed to establish successful risk management in a VO.

ISM offers a method that helps SMEs to organise the relations between a number of issues that may impact on decisions and, in order to achieve this, it has been used to

address a number of problems within organisations in relation to decision making. It has been in use as a technique to support the taking of decisions over a substantial period, going back as far as the late 1960s and early 1970s (Bhargava and Power 2001). However, it is only very recently that it has been applied and investigated by researchers in relation to a range of topical areas.

If organisations are able to understand sources of risk then they will also be better able to deal with them or at least plan for their occurrence. This chapter will examine the structural modeling tools as a basis for ISM methodology. The application of ISM as it is treated in the literature is also considered. The centre of this chapter deals with the ISM approach, including the collection of data, SSIM, reachability matrix, level partitions, how the ISM model is formed, the analysis of relationships and classification of the sources of risk, with a discussion and the conclusion to end.

6.2 Structural Modeling

Structural modeling aims to show clearly how a complicated issue or system or a field of study is structured through the use of graphics and words using patterns that have been precisely defined (Warfield, 1990). Where it is necessary to use mathematical quantification this can be included so that the qualitative geometric representation becomes semi-quantitative. However, it is the geometrics that are emphasised by structural modeling rather than any algebraic aspects. Form and structure are explained through the use of structural models rather than any measurement of quantitative output. According to Linstone et al. (1979) what structural modeling does is, in effect, provide an elementary mapping of a complex system that is able to clarify to a considerable extent the likely potential consequence of links between various elements in a system.

6.3 Structuring Tools

The set of elements involved are configured into a structural model by the structuring tools with the emphasis in this phase being on the relationships between the elements. A pair-wise relationship between all the elements is taken into consideration by the structuring tools, although research is currently being undertaken to enhance the capacity of these tools so that they are able to consider more wide-ranging relations. Structure is represented graphically by points (or nodes), and by connecting lines (or

arcs), the two together defining a graph. Where there is an ordering or direction specified for each connecting line, the graph becomes a directed graph or diagraph. Weights and/ or signs for the arcs may be added to make signed diagraphs. There may be two elements within a graph or diagraph that are connected by more than one line (cycle) (Sharma et al., 1995).

6.4 ISM Methodology

This section will give an explanation of why the ISM methodology was chosen for this study. This is followed by details of the methodology of ISM, bearing in mind that where problems lack definition they tend to be dynamic in nature rather than involving human factors.

Where problems lack definition soft systems methodology (SSM) is most often used since, initially, it is not possible to see an obvious objective that is clearly defined. However SSM has the problem that it can only be used to address certain defective parts of a system but is not capable of constructing a system as a whole. It is also very time-intensive (Ravi et al., 2005). Information relating to technology, business, education, science, and other fields can be forecast using the Delphi method which is able to reach a consensus between a group of experts by following a sequence of steps. The disadvantage of the Delphi method, however, is that it relies on questionnaires and it may be difficult to collect these from people who are already busy. What structural equation modeling (SEM) provides is an approach that is able to confirm data analysis which requires an a priori assignment of inter-variable relationships. It makes a statistical check on an hypothesised model to ascertain the extent to which the proposed model accords with the sample data (Schumacker and Lomax, 1996, Wisner, 2003). The fact that the existence of statistical data is necessary before SEM can produce a result is one of its limitations.

Nonetheless, in comparison with the methods described previously, there are many advantages to using the ISM methodology. This research aims to decrease the risks in SMEs collaboration which in a virtual organisation stem from a number of sources. The construction of a model able to show these risk sources so that any collaboration using it would be better able to achieve the results at which it aims, would be of significant value. In such circumstances the use of ISM is valid, since based on the

relationships between the sources, it should be possible to build an overall structure for the system to be considered. It is intended that ISM should be first and foremost a group learning process but it can also be used on an individual basis (Sage, 1977). The ISM is able to change material that lacks clarity and has been poorly expressed into models that are visible and well-defined and that can be used for a number of purposes.

What the methodology of ISM provides is a group learning process where a number of basic ideas of graph theory are applied systematically so that leverage is made use of in relation to theories, concepts and computation in order to provide an explanation of the complicated patterns of contextual relationships that exist within a set of variables (Malone, 1975). ISM is designed to use to provide an approach that is both logical and systematic when an issue that is complex is being considered, and it is able to provide a tool which can bring order and direction to the complex relations existing between a number of elements (Sage, 1977; Singh et al., 2003; Jharkharia and Shankar, 2005).

ISM methodology was used by Saxena et al. (1992) in relation to the Indian cement industry in order to model the variables of energy conservation and they were able to identify the key variables by the use of direct and indirect interrelationships between them. ISM methodology was also used by Sharma et al. (1995) in order to determine a hierarchy of the necessary action to be taken to achieve the objective for waste management in India in the future. Mandal and Deshmukh (1994) utilised ISM to make an analysis of some of the central criteria for vendor selection and have demonstrated how criteria are related and the levels of interrelatedness. These criteria have also been categorised by them in relation to their driving power and dependence. Within the computer industry the reverse logistics operations are driven by a number of variables with an assessment of the direct and indirect relationships between them offering a clearer picture of the situation than could be achieved by considering each variable in isolation.

Table (6-1) provides a summary of those applications of ISM which have been used by researchers from 1992 to date in order of considered the system that is being to increase understanding of it.

Table 6-1 ISM Application Found in the Literature

Researchers	System under consideration
1. Saxena et al. (1992)	Energy conservation
2. Mandal and Deshmukh (1994)	Vendor selection
3. Sharma et al. (1995)	Waste management in India
4. Kanungo and Bhatnagar (2001)	Information system quality
5. Ravi and Shankar (2004)	Reverse logistics barriers
6. Ilyas et al. (2005)	Digital enablement leading to effective value-chain
7. Jharharai and Shankar (2005)	IT enablement of supply chains: understanding the barriers
8. Ravi et al. (2005)	Productivity improvement in supply chains
9. Bolanos et al. (2005)	Strategic decision making
10. Jharharai and Shankar (2005)	IT enablement of supply chains: modeling the enablers
11. Faisal et al. (2006)	Risk mitigation in supply chains
12. Faisal et al. (2006)	Information risk in supply chains
13. Singh and Grag (2007)	Improving competitiveness of SMEs
14. Hassan et al. (2007)	Agile manufacturing barriers
15. Faisal et al. (2007)	Information risks management in supply chains
16. Faisal et al. (2007)	Supply chain risk management in SMEs
17. Faisal et al. (2007)	Risk mitigation environment of supply chains
18. Agarwal et al. (2007)	Agility of supply chain
19. Grover et al. (2007)	Corporate governance
20. Kant and Singh (2008)	Knowledge management barriers
21. Charan et al. (2008)	Supply chain performance measurement system
22. Thakkar et al. (2008)	Evaluation of buyer-supplier relationships
23. Thakkar et al. (2008)	IT-enablers for Indian manufacturing SMEs
24. Faisal et al. (2008)	Virtual Integration and Information Risks
25. Anantatmula (2008)	The role of technology in the project manager performance model
26. Raj et al. (2008)	Flexible manufacturing systems
27. Kannan et al. (2008)	Analysis and selection of green suppliers
28. Bhattacharya and Momya (2009)	Growth enablers in construction companies

The theory put forward by Kelly (1955) of personal constructs enables use to be made of the points of view of individuals, either individually or collectively in order to give meaning to complex relationships. According to his theory individuals analyse their experiences to enable them to produce a system of constructs that are then used to anticipate future actions they may meet. In situations where individuals encounter changed circumstances, they reconfigure their system of constructs in order to make sense of it. Hebel (2000) supports this theory that formalises the relationship between human value systems and technological change and in doing so shows behaviour as emerging from the changing and changed situation.

So that this rich conceptual structure could be maintained and also to maintain the idea of a 'person as scientist' it was necessary for the research methodology to be one which invited participation. It was also felt to be necessary that those participating in the research should go beyond the central issues in order to make an evaluation of how more immediate issues interact (Morgando et al., 1995).

The methodology of ISM can meet the research needs that have been outlined above, being a proven methodology that allows individuals to chart complicated relationships between a number of elements in complex circumstances. Since the study is a qualitative one, it is possible to make an analysis after applying a framework for evaluation that answers the concerns arising from multiple points of view, which is able to recognise and incorporate subjectivity, which is also based on an hierarchy and able to respond to the concerns of the researcher, and therefore ISM was chosen (Sage, 1977).

Risk sources affecting VOs both directly and indirectly were identified based on a review of the literature. A questionnaire was prepared and administered in order to test the validity of each factor (through verifying that each item in the questionnaire was understandable) as well as to facilitate an understanding of any additional factors that could affect VOs.

6.5 Interpretive Structural Modeling (ISM)

ISM is one of the Interactive Management methods which assist research groups in dealing with complex issues (Warfield, 1974; 1990; 2005). ISM transforms unclear, poorly articulated mental models of a system into visible well defined, hierarchal models. It is a well known methodology for identifying and summarising relationships among specific elements, which define an issue or a problem, and provide a means by which order can be imposed on the complexity of such elements (Mandal and Deshmukh 1994). Thus, a set of different and directly related elements are structured into a comprehensive systematic model. ISM is primarily intended as a group learning process, but individuals may also apply it (Ravi and Shankar, 2005, Faisal et al., 2007).

ISM is able to bring together contributions from individuals having a range of differing views, perspectives and backgrounds through use of a process that has

structure and is both collaborative and comprehensive. The participants were made up of a group that has wide knowledge of the situation in which they are involved and who are able to:

1. Develop together a deep understanding of the current situation.
2. Establish a clear basis from which to consider the future.
3. Leading to the production of a framework for effective action (Warfield, 1974).

The two concepts that underpin ISM and that are vital to understand both the process and product of ISM must be considered, the first being reachability and the second the concept of transitive inference (Watson, 1978). It is these two concepts together with the book-keeping capacity of computers that enable ISM to provide a formal approach to structuring complicated systems, the claim of which is to provide a system that is both more efficient and effective than approaches that are less formal and unassisted (Watson , 1978).

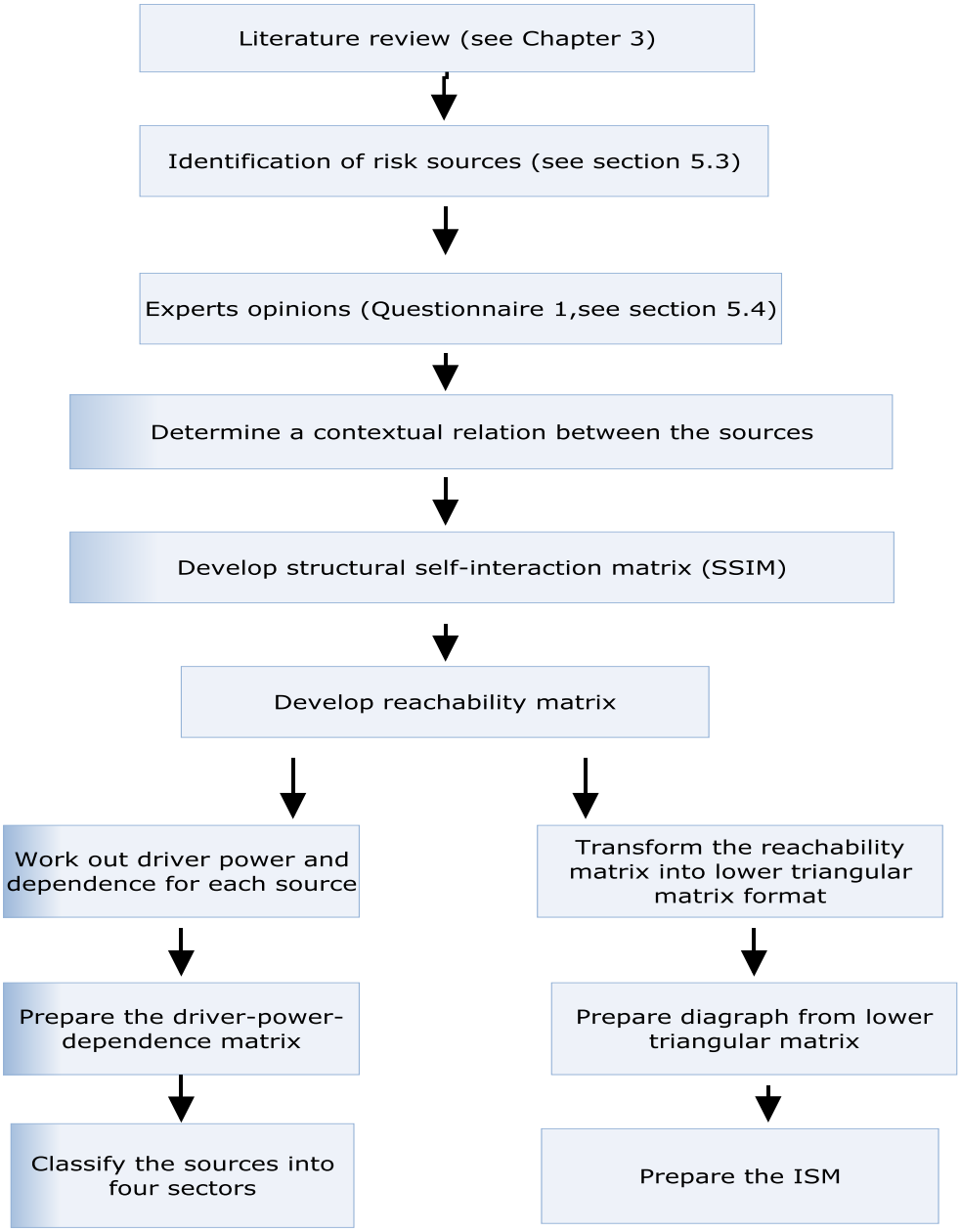

Figure 6-1 ISM Structure

In chapter 5 thirteen sources of risk for VOs were identified (see Table 5.1) with these risks having the potential to cause failure to meet delivery time, targets for costs and quality or even the complete failure of a collaboration. These risk sources were used to develop questionnaire 2 using ISM methodology, in order to ascertain the basic relations between these sources.

6.5.1 Questionnaire 2

After establishing the set of VO risk sources (Chapter 5), an understanding of the relationships between these sources using ISM was arrived at. Two sources at a time were dealt with. Questionnaire 2 was circulated and respondents were asked to complete it. The number of questions that the questionnaire contains is N (N-1)/2 where N is the number of variables between which relationships will be investigated. Since there are 13 risk sources, the number of questions is 13(13-1)/2 = 78.

The questionnaire was distributed via the INTEROP-VLab mailing list which contains 224 members. INTEROP-VLab is the "International Virtual Laboratory or Enterprise Interoperability", officially created as an AISBL (Association Internationale Sans But Lucratif) under Belgian law. INTEROP-VLab derives from the Network of Excellence INTEROP-NoE (Interoperability Research for Networked Enterprise Applications and Software, FP6), coordinated by the University of Bordeaux 1. INTEROP-VLab aims to develop, strengthen and maintain in a lasting way the new European research community that INTEROP-NoE set up in the three and a half years that it spent in activities aimed at concentrated integration, joint research and dissemination of information in the area of Enterprise Interoperability.

INTEROP-VLab is a virtual research organisation that has the capacity to combine laboratories that currently exist as well as future laboratories in close connection with industry in order to attain a number of targets that would go beyond the capacity of each participant operating individually (www.interop-vlab.eu, 2009).

Table 6-2 INTEROP-VLab Members and Organisations

Country	China	Spain	France	Germany	UK	Portugal	Italy	Norway Sweden Finland	Total
People	64	33	49	14	9	7	33	15	224
Organisation	13	7	15	10	5	4	9	8	71

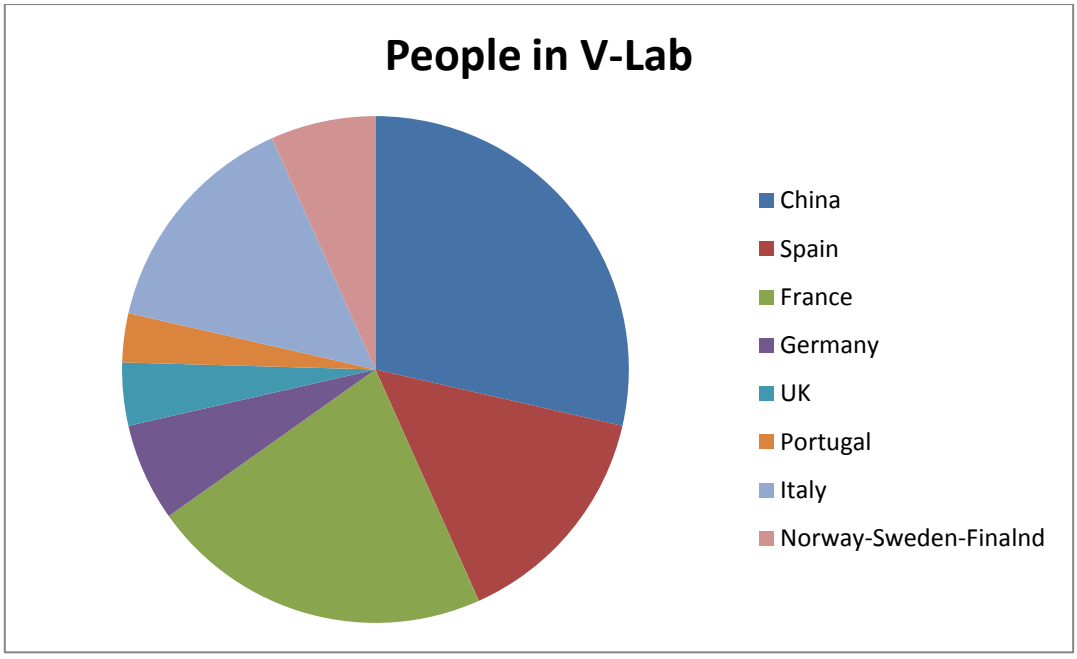

Figure 6-2 People in V-Lab

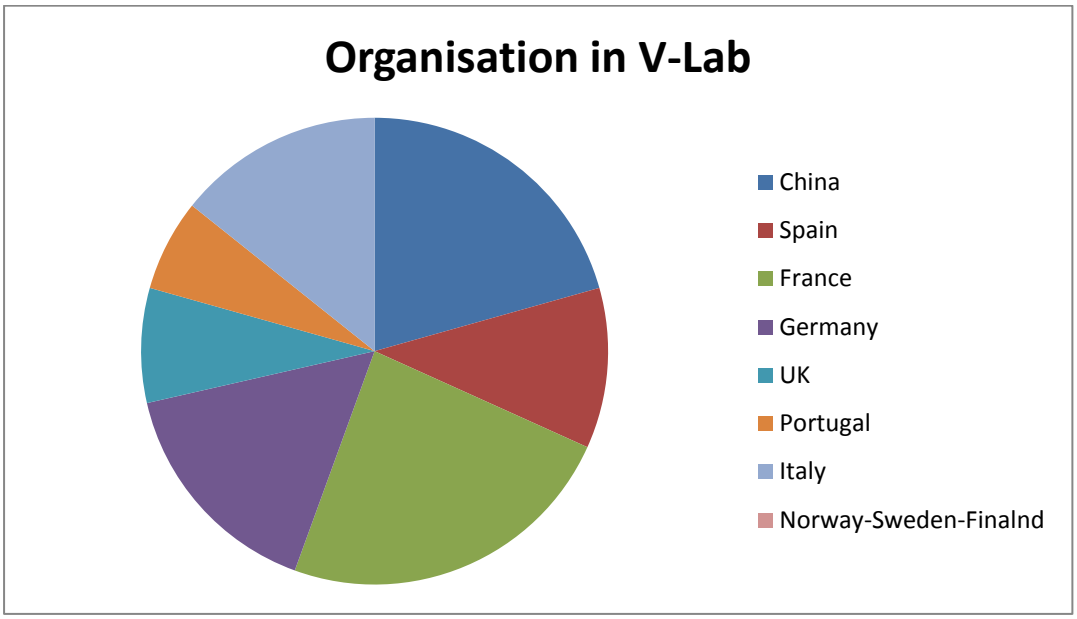

Figure 6-3 Organisations in V-Lab

The organisations participating in the INTEROP-VLab are made up of 78% universities, 9% centres for research, 10% companies (industry and SMEs), with a further 3% being associations of SMEs (Figure 6-4)

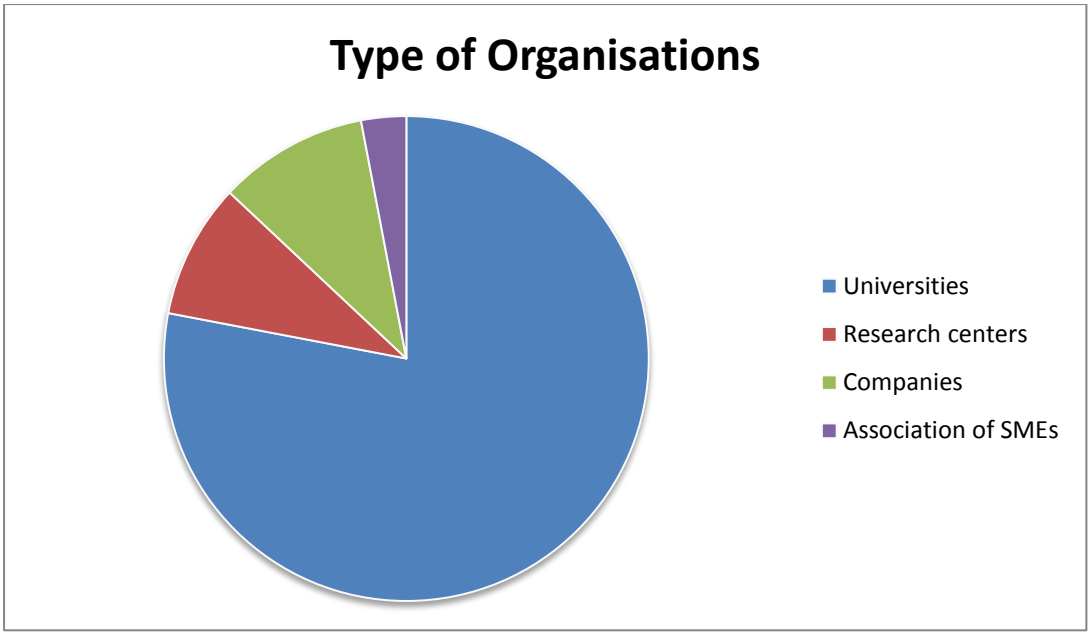

Figure 6-4 Types of Organisations in V-Lab

6.5.2 Interpretive Structural Modeling Approach

Once the set of VO risk sources has been established, it is possible to understand the shared underlying organisational framework in which these sources exist using ISM.

Human brains are limited in dealing with complex problems involving a significant number of elements and relations among the elements (Waller, 1975). However, with the use of ISM, two elements can be dealt with at a time.

ISM is a process that helps people to structure their collective knowledge and to model interrelationships in a way that enhances their ability to understand complexity. In other words, it helps to identify structure within a system of related elements and provides an opportunity to analyse it from several viewpoints. Table (6-3) is a summary of the questionnaire for the survey, where respondents were asked to answer in the upper right cells of the matrix, shown by following the direction provided below of the matrix, where every cell summarises a question.

Table 6-3 Summary of ISM Questionnaire

Risk sources	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Lack of trust between partners													
2. Inadequate collaboration agreement													
3. Heterogeneity of partners													
4. Ontology differences													
5. Structure and design													
6. Loss of communication													
7. Culture differences													
8. Bidding for several VO at the same time													
9. Lack of Information sharing													
10. Lack of top management commitment													
11. Lack of knowledge about risks													
12. Wrong partner/s selection													
13. Geographic location													

Contextual relationship = leads to

What should be entered in the white cells.

Enter **V** when the row influences the column.

Enter **A** when the column influences the row.

Enter **O** when there is no relation between the row and the column.

Enter **X** when row and column influence each other.

ISM helps to identify structure within a system of related elements and provides the opportunity to analyse it from several viewpoints. The questionnaire was presented to the respondents in the survey, and respondents were asked to fill it out. Respondents were asked to answer a total of 78 questions, with each cell in the upper right cells representing a question. Respondents were asked to compare the column statement with the row statement for each cell and to choose a value from the set (V, A, O, or X). These symbolic values (V, A, X, or O) are translated into binary values to develop

a directional graph. The detailed ISM methodology used to develop the directional graph is explained below. The contextual relation is established based on a pair-wise assessment of all the thirteen risk sources as shown in (Table 6-4), and the majority (70%) of the respondents agreeing to a specific relation between any two sources. With the use of this methodology it is possible to identify the direct and indirect relationships between risk sources in the VO.

6.5.3 Data Collection

A total of 45 INTEROP-VLab members participated in the study. Using the research data collected from these respondents and following the steps described below, the ISM directional graph has been developed.

Steps involved in ISM methodology which are summarised in (Figure 6-5) are as follows:

1. Identification of the variables those are relevant to the problem or issue.
2. From the variables identified in the first step, establishing the contextual relationship among them. This represents the relationship indicating whether or not one source leads to another.
3. Developing a structural self-interaction matrix (SSIM) of sources which indicates a pair-wise relationship between sources of the system under consideration.
4. Developing a reachability matrix from the SSIM, and checking the matrix for transitivity. The SSIM format is transformed to the format of the reachability matrix by transforming the information in each entry of the SSIM into 1s and 0s in the reachability matrix.
5. The reachability matrix obtained in the fourth step is partitioned into different levels.
6. Based on the relationships in the reachability matrix, removal of the transitive links and drawing a directed graph.
7. Constructing the ISM model by replacing element nodes with statements.
8. The ISM model developed in the seventh step is reviewed to check for conceptual inconsistency, and to make the necessary modifications.

These steps, mentioned above which lead to the development of the ISM model, are discussed below.

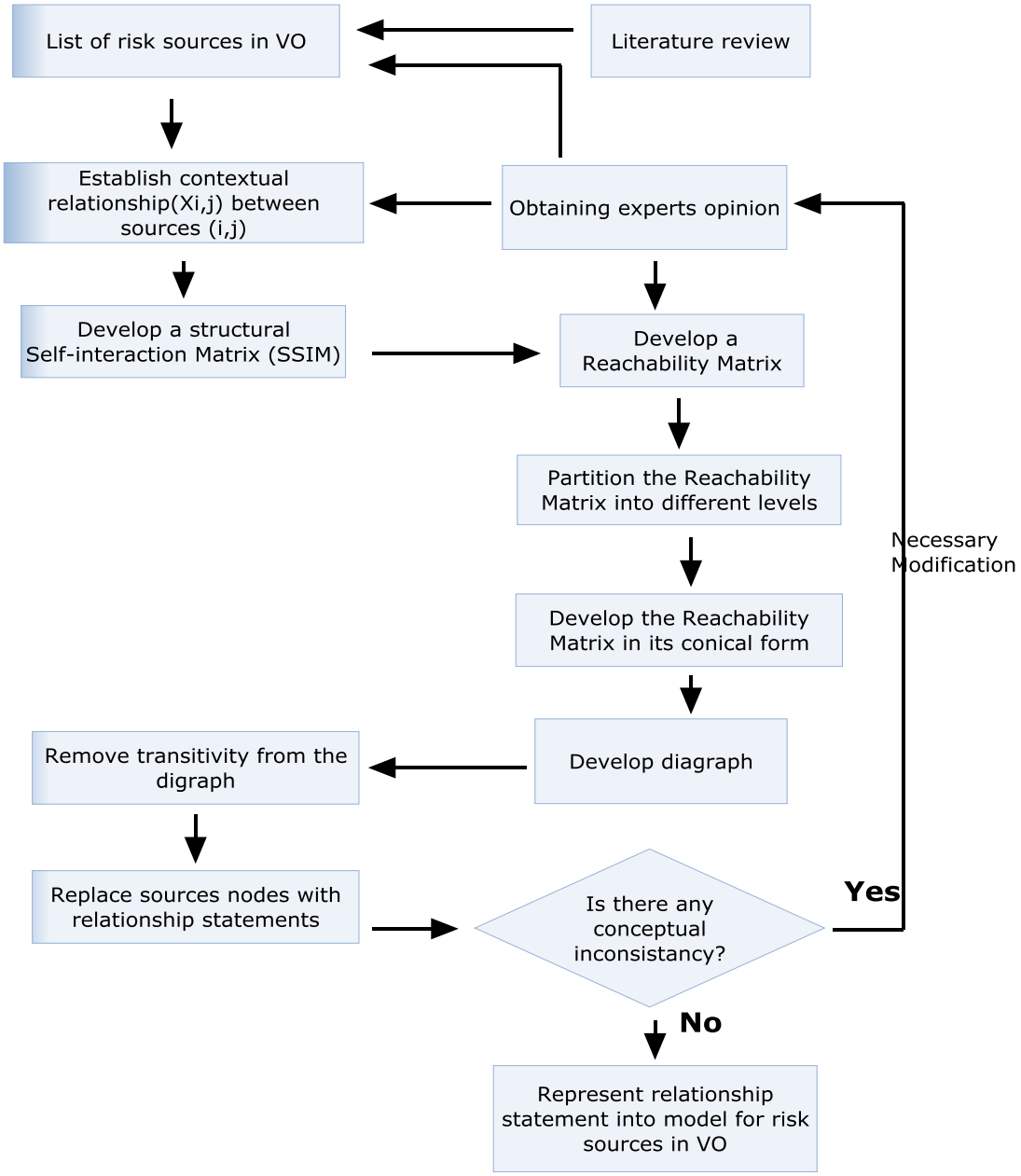

Figure 6-5 Flow Diagrams for Preparing ISM

6.5.4 The Structural Self-Interaction Matrix (SSIM)

ISM methodology suggests the use of the expert opinions in developing the contextual relationship among the sources. The approach relies on academic experts or experts from a managerial background from the INTEROP-VLab who answered our

questionnaire with their opinions, in order to arrive at the structure and relationship of the risk sources.

Keeping in mind the contextual relationship for each source, the existence of a relationship between any two sources (i and j) and the associated direction of the relationship are questioned. Four symbols are used to denote the direction of relationship between the sources (i and j):

V –source i will lead to source j;

A -source j will lead to source i;

X -source i and j lead to each other; and

O-source i and j are unrelated.

Based on the contextual relationships the SSIM (Table 6-4) is developed for the 13 sources identified for the risk in the VO.

Table 6-4 Structural Self-Interaction Matrix (SSIM)

Risk sources	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Lack of trust between partners		A	A	A	A	A	A	V	X	X	O	V	A
2. Inadequate collaboration agreement	V		O	A	O	V	O	V	V	V	V	V	O
3. Heterogeneity of partners	V	O		O	V	V	O	V	V	V	V	V	O
4. Ontology differences	V	V	O		O	V	O	V	V	V	V	V	O
5. Structure and design	V	O	A	O		V	O	V	V	V	V	V	O
6. Loss of communication	V	A	A	A	A		A	V	V	V	V	V	A
7. Culture differences	V	O	O	O	O	V		V	V	V	V	V	O
8. Bidding for several VO at the same time	A	A	A	A	A	A	A		O	A	V	V	A
9. Lack of information sharing	X	A	A	A	A	A	A	O		X	V	V	A
10. Lack of top management commitment	X	A	A	A	A	A	A	V	X		O	V	A
11. Lack of knowledge about risks	O	A	A	A	A	A	A	A	A	O		V	A
12. Wrong partner/s selection	A	A	A	A	A	A	A	A	A	A	A		A
13. Geographic location	V	O	O	O	O	V	O	V	V	V	V	V	

6.5.5 Reachability Matrix

The SSIM (Table 6-4) is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the case. The rules for the substitution of 1s and 0s are as follows:

- if the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;
- if the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;
- if the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1 ;
- if the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

An initial reachability matrix for the sources is derived following these simple rules. The final reachability matrix is obtained by incorporating the transitivities as enumerated in step 4 of the ISM methodology. The final reachability matrix is shown in Table (6-5). In this table, the driving power of a particular source is the total number of sources (including itself) that it influences. The dependences is the total number of sources (including itself) that it may help to influence its growth. These driving power and dependency values will be used in a classification of risk sources (MICMAC analysis).

Table 6-5 Reachability Matrix

Risk source	1	2	3	4	5	6	7	8	9	10	11	12	13	Driver
1. Lack of trust between partners	1	0	0	0	0	0	0	1	1	1	0	1	0	5
2. Inadequate collaboration agreement	1	1	0	0	0	1	0	1	1	1	1	1	0	8
3. Heterogeneity of partners	1	0	1	0	1	1	0	1	1	1	1	1	0	9
4. Ontology differences	1	1	0	1	0	1	0	1	1	1	1	1	0	9
5. Structure and design	1	0	0	0	1	1	0	1	1	1	1	1	0	8
6. Loss of communication	1	0	0	0	0	1	0	1	1	1	1	1	0	7
7. Culture	1	0	0	0	0	1	1	1	1	1	1	1	0	8
8. Bidding for several VO at the same time	0	0	0	0	0	0	0	1	0	0	1	1	0	3
9. Information sharing between partners	1	0	0	0	0	0	0	0	1	1	1	1	0	5
10. Lack of top management commitment	1	0	0	0	0	0	0	1	1	1	0	1	0	5
11. Knowledge about risks	0	0	0	0	0	0	0	0	0	0	1	1	0	2
12. Wrong partner/s selection	0	0	0	0	0	0	0	0	0	0	0	1	0	1
13. Geographic location	1	0	0	0	0	1	0	1	1	1	1	1	1	8
Dependence	10	2	1	1	2	7	1	10	10	10	10	13	1	

6.5.6 Level Partitions

The reachability and antecedent set (Warfield, 1974) for each source are obtained from the final reachability matrix. The reachability set for a particular source consists of the variable itself and the other sources which it influences. The antecedent set consists of the source itself and the other sources which may influence it. Subsequently, the common sources of the reachability and antecedent sets from the intersection sets are the same as assigned as the top-level source in the ISM hierarchy, as it would not help achieve any other source above their own level. After the identification of the top-level source, it is discarded from the list of remaining

sources. Thus, it would be positioned at the top of the ISM hierarchy. This iteration is repeated till the levels of each source are identified (Tables 6-6 till 6-12). The identified levels aid in building the diagraph and the final model of ISM.

Table 6-6 Iteration 1

Risk source	Reachability set	Antecedent set	Intersection set	Level
1. Lack of trust between partners	1,8,9,10,12	1,2,3,4,5,6,7,9,10,13	1,9,10	-
2. Inadequate collaboration agreement	1,2,6,8,9,10,11,12	2,4	2	-
3. Heterogeneity of partners	1,3,5,6,8,9,10,11,12	3	3	-
4. Ontology differences	1,2,4,6,8,9,10,11,12	4	4	-
5. Structure and design	1,5,6,8,9,10,11,12	3,5	5	-
6. Loss of communication	1,6,8,9,10,11,12	2,3,4,5,6,7,13	6	-
7. Culture differences	1,6,7,8,9,10,11,12	7	7	-
8. Bidding for several VO at the same time	8,11,12	1,2,3,4,5,6,7,8,10,13	8	-
9. Lack of information sharing	1,9,10,11,12	1,2,3,4,5,6,7,9,10,13	1,9,10	-
10. Lack of top management commitment	1,8,9,10,12	1,2,3,4,5,6,7,9,10,13	1,9,10	-
11. Lack of knowledge about risks	11,12	2,3,4,5,6,7,8,9,11,13	11	-
12. Wrong partner/s selection	12	1,2,3,4,5,6,7,8,9,10, 11,12,13	12	1
13. Geographic location	1,6,8,9,10,11,12,13	13	13	-

Table 6-7 Iteration 2

Risk source	Reachability set	Antecedent set	Intersection set	Level
1. Lack of trust between partners	1,8,9,10	1,2,3,4,5,6,7,9,10,13	1,9,10	-
2. Inadequate collaboration agreement	1,2,6,8,9,10,11	2,4	2	-
3. Heterogeneity of partners	1,3,5,6,8,9,10,11	3	3	-
4. Ontology differences	1,2,4,6,8,9,10,11	4	4	-
5. Structure and design	1,5,6,8,9,10,11	3,5	5	-
6. Loss of communication	1,6,8,9,10,11	2,3,4,5,6,7,13	6	-
7. Culture differences	1,6,7,8,9,10,11	7	7	-
8. Bidding for several VO at the same time	8,11	1,2,3,4,5,6,7,8,10,13	8	-
9. Lack of information sharing	1,9,10,11	1,2,3,4,5,6,7,9,10,13	1,9,10	-
10. Lack of top management commitment	1,8,9,10	1,2,3,4,5,6,7,9,10,13	1,9,10	-
11. Lack of knowledge about risks	11	2,3,4,5,6,7,8,9,11,13	11	2
13. Geographic location	1,6,8,9,10,11,13	13	13	-

Table 6-8 Iteration 3

Risk source	Reachability set	Antecedent set	Intersection set	Level
1. Lack of trust between partners	1,8,9,10	1,2,3,4,5,6,7,9,10,13	1,9,10	-
2. Inadequate collaboration agreement	1,2,6,8,9,10	2,4	2	-
3. Heterogeneity of partners	1,3,5,6,8,9,10	3	3	-
4. Ontology differences	1,2,4,6,8,9,10	4	4	-
5. Structure and design	1,5,6,8,9,10	3,5	5	-
6. Loss of communication	1,6,8,9,10	2,3,4,5,6,7,13	6	-
7. Culture differences	1,6,7,8,9,10	7	7	-
8. Bidding for several VO at the same time	8	1,2,3,4,5,6,7,8,10,13	8	3
9. Lack of information sharing	1,9,10	1,2,3,4,5,6,7,9,10,13	1,9,10	3
10. Lack of top management commitment	1,8,9,10	1,2,3,4,5,6,7,9,10,13	1,9,10	-
13. Geographic location	1,6,8,9,10,13	13	13	-

Table 6-9 Iteration 4

Risk source	Reachability set	Antecedent set	Intersection set	Level
1. Lack of trust between partners	1,10	1,2,3,4,5,6,7,10,13	1,10	4
2. Inadequate collaboration agreement	1,2,6,10	2,4	2	-
3. Heterogeneity of partners	1,3,5,6,10	3	3	-
4. Ontology differences	1,2,4,6,10	4	4	-
5. Structure and design	1,5,6,10	3,5	5	-
6. Loss of communication	1,6,10	2,3,4,5,6,7,13	6	-
7. Culture differences	1,6,7,10	7	7	-
10. Lack of top management commitment	1,10	1,2,3,4,5,6,7,10,13	1,10	4
13. Geographic location	1,6,10,13	13	13	-

Table6-10 Iteration 5

Risk source	Reachability set	Antecedent set	Intersection set	Level
2. Inadequate collaboration agreement	2,6	2,4	2	-
3. Heterogeneity of partners	3,5,6	3	3	-
4. Ontology differences	2,4,6	4	4	-
5. Structure and design	5,6,	3,5	5	-
6. Loss of communication	6	2,3,4,5,6,7,13	6	5
7. Culture differences	6,7	7	7	-
13. Geographic location	6,13	13	13	-

Table 6-11 Iteration 6

Risk source	Reachability set	Antecedent set	Intersection set	Level
2. Inadequate collaboration agreement	2	2,4	2	6
3. Heterogeneity of partners	3,5	3	3	-
4. Ontology differences	2,4	4	4	-
5. Structure and design	5	3,5	5	6
7. Culture differences	7	7	7	6
13. Geographic location	13	13	13	6

Table 6-12 Iteration 7

Risk source	Reachability set	Antecedent set	Intersection set	Level
3. Heterogeneity of partners	3	3	3	7
4. Ontology differences	4	4	4	7

6.5.7 Formation of ISM-based Model

The structural model (Figure 6-6) is generated from the final reachability matrix and the diagraph is drawn. Removing the transitivities as described in the ISM methodology, the diagraph is finally converted into the ISM. The contextual relationship for this structure was “leads to”. This implies that each arrow is read as “leads to”.

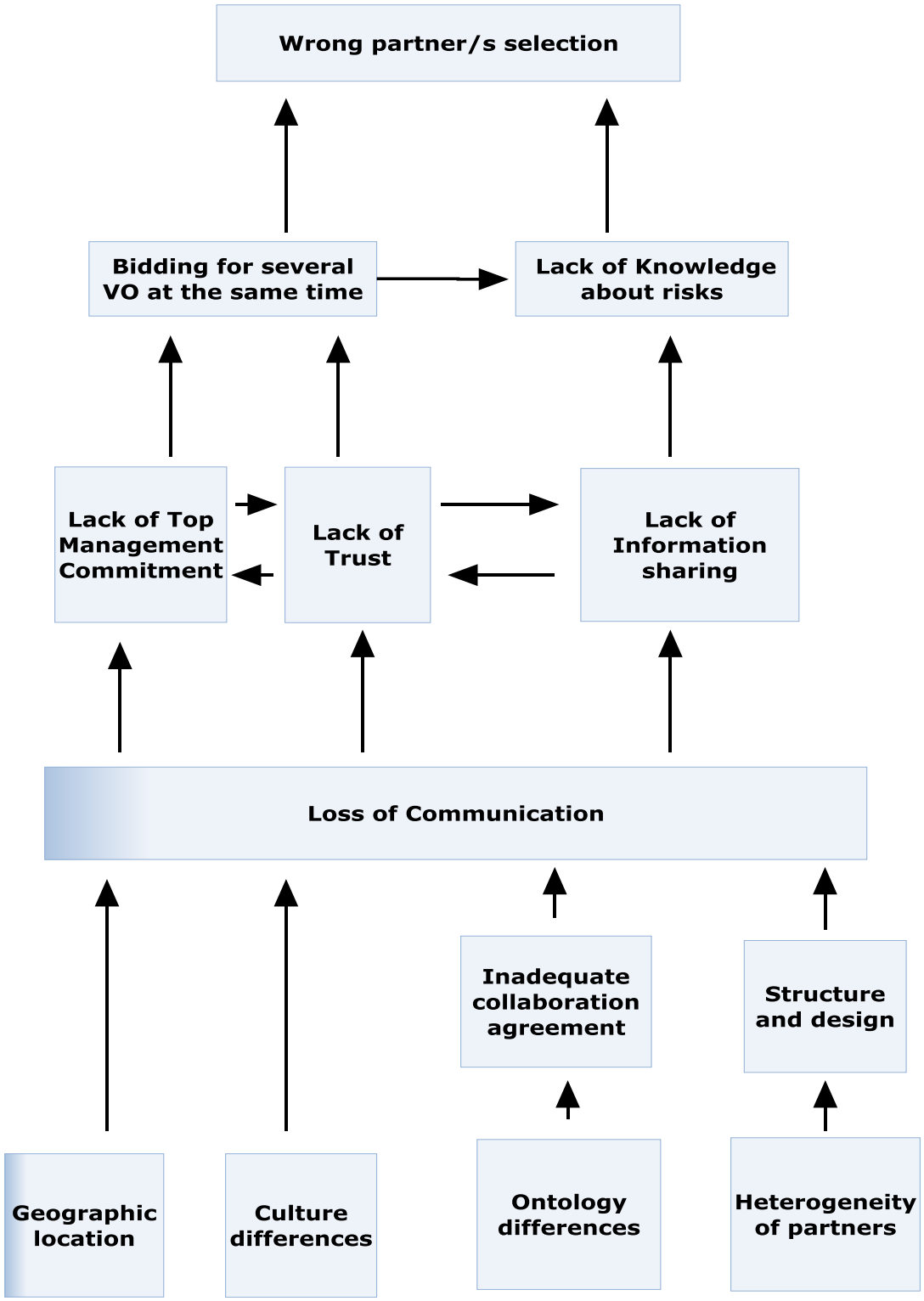

Figure 6-6 ISM model

6.6 Types of Maps

Each relation map produced as a result of the process of ISM corresponds directly to what are known as diagraphs in the mathematical theory of graphs. In mathematical terminology the elements are known as the vertexes of the diagram, and the lines with arrows as, variously, edges or arcs. Several types of map exist which are classified according to structural features. A single element unconnected to anything else is called an isolated element. Where all the elements in it are isolated, the map is known as an array. If a pair of elements is related in both directions, the elements are called cyclic. When a map contains walks but no cycles it is called a hierarchy. A hierarchy, therefore, is a map that has walks but no cycles, a walk being a prose statement associated with a map with the total number of walks on the map being countable. It follows that a hierarchy provides no feedback. The mixed structure, such as the one above, is the most general type: it contains at least one cycle and if each of its maximal cycles is replaced with a single 'proxy' element what results will be a hierarchy. It is possible for all the types outlined above to appear in applications (Saxena et al., 1990).

6.7 Analysis of Relationships

6.7.1 Direct Relationship Analysis

Only the direct relationship between sources can be seen by examining the diagraph that represents the structure developed by a structuring tool. The diagraph could be examined more methodically by examining the relation between the sources since it is this that impacts upon the problem being analysed.

The latent power of a source to drive other sources as well as the dependence of any one source upon others provide the most common examples of the relationship between sources. It is important to identify any sources that can affect a number of other sources or that might be affected by a number of others. Since structuring tools are only able to look at direct relations between sources, the diagraph is only able to analyse direct relations. In order to identify the way that sources affect each other a direct relationship matrix (Saxena et al., 1990) can be acquired by looking at the direct relationship between sources as shown by a diagraph. This direct relationship

matrix differs from the minimum edge adjacency matrix since it can consider account feedbacks also. The driver power of any source can be obtained by summing up the number of interactions in the rows and its dependence by summing up the number of interactions in the columns. Subsequently driver power and dependence ranks are worked out by giving highest ranks to the sources that have the maximum number of interaction in the rows and columns, respectively.

6.7.2 Indirect Relationship Analysis

Where complex problems exist within a group, the behaviour of the system will be influenced by indirect relations through chains of influence and reaction loops but it is not possible to show these in a direct relationship matrix. Where the number of these chains and loops are very large, a computer may be necessary to help to interpret the relationships. The MICMAC (Duperrin and Godet, 1973) method provides a system for manipulating matrices that can be used for this indirect relationship analysis. Duperrin and Godet (1973) developed this system which enables the study of impacts through reaction paths and loops as they appear in developing hierarchies for members of an element set. It is usual for two hierarchies to be developed, one based on driver power and the second based on independence with the method for calculating the driver power and dependence ranks at each step being the same as set out above.

MICMAC is the acronym for Matrice d'Impacts croises-multiplication appliqué an classement (Cross-impact matrix multiplication applied to classification). According to the MICMAC principle and based on the multiplication properties of matrices, if element A directly influences element B and B directly influences element C, then any change affecting A can have repercussions on C. Therefore, there is an indirect connection between A and C that it is not possible to show on a direct relationship matrix. However, when that matrix is squared using Boolean algebra, second-order relations are revealed such as A to C. Proceeding in the same fashion if 3^{rd}, 4^{th}, 5^{th}, … nth powers of the direct relationship matrix are obtained, then 3^{rd}, 4^{th}, 5^{th}… nth order indirect relationships will be revealed. It is possible to deduce a new hierarchy among the elements, every time the process is repeated. When raised to a certain power, if this hierarchy repeats in the next stage of multiplication within the hierarchy, there

will be the MICMAC classification and this can be used to study indirect relations minutely.

6.8 Classification of the Risk Sources (MICMAC analysis)

MICMAC was developed by Duperrin and Godet (1973) to study the diffusion of impacts through reaction paths and loops for developing hierarchies for members of an element set. MICMAC analysis can be used to identify and analyse the elements in a complicated system (Warfield, 1990). Generally, the elements will be classified into four clusters of autonomous, dependent, linkage and independent (driver) sources according to the driving power and dependencies of all the elements (Ravi and Shankar, 2005).

The objective of the MICMAC analysis is to analyse the driving power and the dependence of the elements (Mandal and Deshmukh, 1994; Faisal et. al., 2006). In this analysis, the risk sources described earlier are classified into four clusters. The first cluster consists of the "autonomous sources" that have weak driving power and weak dependence. These sources are relatively disconnected from the system, with which they have only a few links, which may not be strong. In the case being studied for this research there are no sources in the autonomous cluster which indicates no sources can be considered as disconnected from the whole system and the management has to pay attention to all the identified risk sources in the VO.

The "dependent sources" constitute the second cluster which has weak driving power but strong dependence. There are six sources in this cluster ; lack of top management commitment, information sharing, trust between partners, bidding for several VOs at the same time, knowledge about risks and wrong partner/s selection. It represents the sources that form the resultant action for risks in a VO. Its strong dependence indicates that it requires all the other risks to come together so as to increase them as VO risks.

The third cluster has the "linkage sources" that have strong driving power and strong dependence. These sources are unstable due to the fact that any change occurring to them will have an effect on other sources and also a feedback to themselves. Just one of the risk sources in this cluster, which is loss of communication, is influenced by lower level sources and in turn impacts other sources in the model.

The fourth cluster includes the "independent sources" having strong driving power but weak dependence. Six risk sources are in this cluster: geographic location, culture, ontology differences, heterogeneity, inadequate collaboration agreement and structure and design. It forms the top level in the ISM hierarchy. These six sources play a key role in risks in a VO.

However, they are important as it is these risks that are finally required to be understood by the SMEs in order to effectively mitigate risks in VO.

Dependence is the total number of sources (including itself), which it may help to instigate. Those sources which are at the second and third levels in the model with highest driving power are known as 'strategic risk sources'.

The objective behind this classification of the risk sources is to analyse the driver power and dependency of sources (Jharkharia and Shankar, 2005). In general, higher sources driver power means that a large number of sources could be easily eliminated by its removal. Higher dependence values for sources require a large set of sources to be addressed before the removal of that source and a more likely success in the implementation of VO risks. The classification of risk sources within the four clusters helps identify the difficulty removal potential of the risk sources.

The driving power and the dependence of each of these sources are shown in (Table 6-5). In this table, an entry of source along the columns and rows indicates the dependence and driving power, respectively. Subsequently, the driver power–dependence diagram is constructed which is shown in (Figure 6-7).

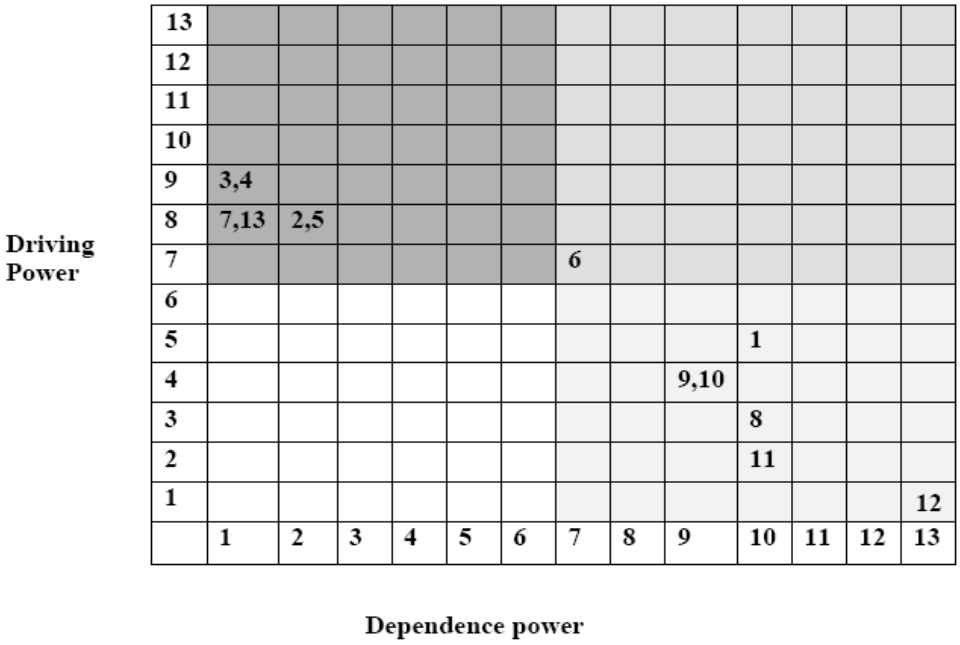

Figure 6-7 MICMAC diagram

6.9 Benefits and Limitations of ISM

The ISM process itself is always part of a wider process and both the benefits that it can confer and the limitations that it has are influenced by and highly dependent upon the overarching process which includes the ISM process. Where the process is regarded as being successful in a particular case, which it usually is, it is certain that the success has derived to a great extent from the skills of the facilitator of the process as well as both the knowledge and attitudes of those taking part. Where the process is considered to have failed, experience would indicate that the main reason for the failure lies in the inadequacy of the facilitator of the process.

The ISM methodology does not have many drawbacks. Such knowledge for those using the system as familiarity with the firm and with the contextual relationship between variables, as well as with the specific operation and industry is important, and it is possible that this could lead to bias in the person judging the variables and this might exert an influence on the ultimate result. It is only possible to use ISM as a tool to impose order and direction on the complicated relationships within the variables; what it cannot do is give the variables an associated weight (Kannan et al., 2008).

The statements within the questionnaire ask for binary assertions but many of the questions are more complex than this would suggest and therefore the responses that are asked for are not always realistic. Those completing the questionnaire may well find it a tiring task since it demands significant concentration and is time consuming.

6.10 Discussion

The objective of the ISM model in this research is to develop a hierarchy of risk sources that would help mitigate risks in VOs. The model developed in this research provides the opportunity to understand the network risk sources in VOs. It is clear that awareness about risk sources is very important as it will lead to efforts being undertaken to minimise these risks. The task of management is to place high priority on those sources that form the basis of the ISM model because it is they who will drive other sources for effective risk alleviation.

The significant features of ISM methodology can be summarised as:

- It provides an understanding of the relationships among the risk sources at the network level in the VO.
- Classification of sources under autonomous, dependent, linkage and independent categories.
- It attempts to develop a new understanding of risks sources due to the SMEs' collaboration.
- Suggested methodology would help the SMEs to develop strategies to mitigate risks.

6.11 Conclusion and Future Work

The aim of this chapter has been to present a description of the process that is known as Interpretive Structural Modeling (ISM). The chapter opened with a brief description of the process, demonstrating it to be the natural outcome of a long sequence of steps in the development of human thinking about the relationships among sources.

Based on the literature review and expert opinions, a number of risk sources in the VO which may have negative effects on the time, cost, quality or total failure for the collaboration, have been identified. The 13 risk sources identified in this research

have significant overlaps and relationships that are sometimes difficult to see. A more complete understanding of these risks sources and their relationships, through logical structure, will help partners to take a more informed decision as to whether to join the VO as the result of the presentation in this research of a description of the ISM process.

ISM can only act as a tool for imposing order and directions on the complexity of relationships among the variables. It does not give any weight associated with the variables (Kannan et al., 2008). Even so this model can be applied with other approaches such as the Analytical Network Process (ANP) (Saaty, 2001), which requires a decision structure to help determine the weights of each source.

Simulation and systems dynamics modeling may also be used to help identify how risk sources in a VO will influence it and its performance results.

A number of directions for further research are suggested by this research. As well as the directions that have already been identified the use of the technique described here in real world settings could be undertaken as well as examining expert opinion to discover whether the list of risk sources is complete and the relationships are in reality as the literature suggests they are.

The sources of risk within VOs have become more integrated and more dependent on the relationships of the partners. Currently businesses make use of extranets and intranets to leverage the sources of risk from the partners in a VO.
As yet only thirteen sources have been identified in order to develop the model but work undertaken in the future may identify further sources of risk to help to develop ISM.

ISM has enabled a model of risk sources for a VO to be developed. The validity of this hypothetical model can be further tested by the use of structural equation modelling (SEM) which means that it will be possible for it to be applied to this model in future research in order to test it. It is possible to test SEM models using LISREL or AMOS software. SEM models are also capable of providing the path coefficients for the various relationships that exist between the sources. This means that it will be able to complement the MICMAC analysis in order to more fully

strengthen understanding about the more important relations to which greater attention needs to be paid.

Chapter 7 Analytical Network Process

7.1 Introduction

This chapter discusses the benefits of AHP/ANP and their advantages over the other Multi-Criteria Decision Methods (MCDM) before discussing Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) methods. It explain the advantages and disadvantages of ANP compared with AHP, before going on to illustrate how ANP can be used to assess risk sources as part of the framework to facilitate and support the final decision of virtual organisation collaboration. Overall, insights from and the process suggested in this research will aid SMEs to make less risky decisions.

Managing risk has become a critical component for the success of SMEs collaboration where the implications of VO failures can be costly and lead to significant losses as discussed earlier. This chapter aims to reinforce the proposal of an integrated methodology to classify, manage and assess network level risk sources in a VO, where these risks sources are identified through both an extensive academic literature review as well as an expert questionnaire as mentioned earlier (Chapter 5). From these sources, a risk source classification structure is created as well as an ANP method being provided which will give greater consistency in the ranking of sources. Using ANP a panel of risk source weights will be established in order to determine which risks pose the most threat so that there can be clear priorities that can be applied to their management and the best way of dealing with them can be found.

7.2 Multi-Criteria Decision Making Methods

It is necessary to investigate and review the existing multi criteria decision making methods first before selecting an appropriate solution for a context. Several methods exist such as Weighted Sum Model (WSM), Weighted Product Model (WPM), AHP, ANP, ELECTRE Method, TOPSIS Method, etc… (Anderson et al., 2003; Curwin and Slark, 2002; Fishburn, 1996; Bowen, 1990). The problem that the MCDM process aims to solve is how to evaluate a set of alternatives in terms of a number of criteria, which themselves are essentially conflicting. Although MCDM methods may be

widely diverse, many of them have certain aspects in common (Triantaphyllou, 2002). A comparison between MCDM methods was carried out by various researchers, which revealed that AHP/ANP possess a number of benefits over other multi-attribute decision methods (Bowen, 1990; Armacost and Hosseini, 1994; Triantaphyllou, 2002; Bhutta and Huq, 2002).

7.2.1 Advantages of AHP/ANP over other MCDM

In this section a brief comparison is made between these two techniques and other MCDM.

Sarkis and Sundarraj (2005) studied the advantages of AHP/ANP over other MCDM methods and claimed that, "the AHP/ANP approach offers several advantages over the other techniques, despite certain drawbacks such as rank reversal and the number of judgment elicitations that are needed".

1. As compared to other MCDM approaches, AHP/ANP does not use complicated techniques, and this helps improve management understanding and the transparency of the technique.
2. They have the supplemental power of being able to mix both quantitative and qualitative factors into a single decision.
3. This approach can be fitted easily together with other approaches to find a solution such as optimisation and goal programming.
4. AHP/ANP may use a hierarchical structuring of the factors involved. The hierarchical structuring is universal to the composition of virtually all complex systems, and is a natural problem-solving paradigm in the face of complexity.
5. In AHP/ANP, judgment elicitations are completed using a decompositional approach, which has been shown in experimental studies to reduce decision-making errors.
6. AHP/ANP has also been validated from the decision makers' perspective as well as in recent empirical studies.
7. AHP/ANP is a technique that can prove valuable in helping multiple parties arrive at an agreed solution due to its structure, and if implemented appropriately can be used as a consensus-building tool.

In this research, the ANP approach is adopted. The size of a particular business does not limit the use of AHP/ANP and it has been widely used in support of decision making in SMEs. AHP/ANP has been used to assess various plans for collaborative action to develop competencies, since it proposes a framework for a system that would support decision-making through cooperation between SMEs (Boucher and Lebureau, 2004). The use of AHP/ANP made possible the development of an evaluation process in order to forecast the prospects for growth in both high-tech and high-growth SMEs (Zhu and Wang, 2004). This was incorporated to other methods that were being used in order to evaluate industry portals for SMEs (Tzu et al., 2005). In order to examine what effect the soft and hard criteria of total quality management of SMEs was having, use was made of AHP/ANP to ascertain to what extent these criteria were being implemented for ISO 9001 certification (Lewis et al., 2006). Although it has had a positive and successful record in industries, AHP/ANP is more useful in its application to proposed models, compared with other methods. Saaty (2001; 2004) developed the AHP/ANP techniques as a method for decision making based on prioritising. Since the 1980s the method of AHP has been used in relation to marketing mix as well as other operational decisions in order to prioritise (Saaty, 1982; 1986; Dyer and Forman, 1989). The AHP approach makes possible the use of a three-stage method which can help to put in place a strategy that is multi-focussed by virtue of being able to recognise the hierarchical structure of the strategies, as well as giving shape to and creating strategies that have a number of orientations (Takala et al., 2006). Competitive pressure generally and that emanating from companies that have had exponential success as a result of their discovery and utilisation of the best practices of others, has led to the creation of a strategic selection model by AHP aimed at improving the performance of manufacturers (Partovi, 1994). In order to deal with lack of precision in the choice of suppliers an approach was made use of which leaned towards AHP since the use of it avoided the difficulty of providing point estimates in relation to criteria weights as well as performance scores in the basic linear weighting model (Barbarosoglu and Yazgac, 1997). Through the application of AHP it was possible to develop a supplier selection system consisting of four different supplier selection systems based on the time frame (long time and short time) and on both logistic and strategic aspects of the existing supplier/customer relationships (Masella and Rangone , 2000).

7.3 Analytic Hierarchy Process and Analytic Network Process

AHP and ANP are two related concepts developed by Saaty (1980; 1994; 1996; 2006). AHP is a mathematical theory of value, reason, and judgement, based on ratio-scales for the analysis of MCDM problems (Saaty, 1980; 1994; Wolfslehner et al., 2005). It helps to model a hierarchical decision problem framework. It also adopts a pair-wise comparison to assign weights to the elements at the criteria and subcriteria levels and finally calculates global weights for assessment taking place at the bottom level (Cheng and Li, 2001). The pair-wise comparison judgments are made with respect to the attributes of one level of hierarchy given the attributes of the next higher level of hierarchy (from the criteria to sub-criteria). In addition, AHP is able to seek for consistent subjective expert judgment via the consistency test.

Despite such achievements, AHP is only able to solve problems with a hierarchically structured model or unidirectional relationships, and it is inappropriate for models that specify interdependent relationships.

ANP is an advanced version of AHP which can model interdependent relationships in decision making frameworks by relaxing the hierarchical and unidirectional assumptions. This approach is also defined as the system-with-feedback approach (Cheng and Li, 2004; Meade and Sarkis, 1998). An ANP model can be generically designed as a control hierarchy (i.e. a hierarchy of subsystems with interdependencies) or a non-hierarchical network which includes decision alternatives as an original element cluster (Saaty, 1996, Wolfslehner et al., 2005).

Interdependencies may be represented by two-way arrows between levels, or if within the same level of analysis, a looped arc (Meade and Sarkis, 1998). In ANP, the preferences of components and attributes are established on a series of pairwise comparisons where the decision maker will compare two components at a time with respect to an upper level ‘control criterion’. In addition, a hierarchical relationship is allowed within the ANP network model, but the existence of a feedback relationship among the levels is only found in ANP. The ANP approach is capable of handling interdependence among elements by obtaining weights through the development of a ‘supermatrix’ (Hamalainen and Seppalainen 1986).

7.3.1 Analytic Hierarchy Process

AHP allows a set of complex issues, which have an impact on the overall objective, to be compared, with the importance of each issue relative to its impact on the solution to the problem being considered. AHP is a comprehensive framework which is designed to cope with the intuitive, the rational, and the irrational when we make multi-objective, multi-criterion and multi-actor decisions with and without certainty for any number of alternatives (Harker and Vargas, 1987). AHP is conceptually easy to use; however, it is decisionally robust so that it can handle the complexities of real world problems (Saaty, 1980). AHP uses a decision making framework that assumes a unidirectional hierarchical relationship between decision levels. The top element of the hierarchy is the overall goal for the decision model. The hierarchy decomposes from the general to a more specific attribute until a level of manageable decision criteria is met. The hierarchy is a type of system where one group of entities influences another set of entities.

AHP allows decision makers to model a complex problem in a hierarchical structure (Figure 7-1). In this method, a simple hierarchical model consists of a goal, criteria and alternatives. In figure (7-1), the hierarchical structure shows the relationships of the goal, criteria and alternatives from the top to the bottom. AHP copes with using original data, experience and intuition in the same model in a logical and thorough way (Forman, 1999). AHP is composed of several previously existing but unassociated concepts and techniques, such as hierarchical structuring, pair-wise comparisons, and the eigenvector method for deriving weights and consistency considerations (Forman, 1999). According to Saaty (1990). This method has three phases: decomposition, comparative judgment and synthesising.

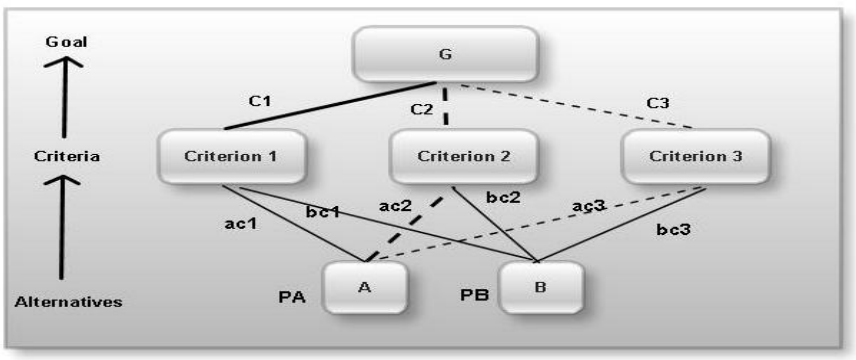

Figure 7-1 A Simple Hierarchical Model

In the decomposition phase, the elements of the decision problem are arranged in the form of a hierarchy. The top element of the hierarchy is the overall goal of the decision making. In the next level, which is known as the cluster, there are general criteria which impact the goal directly. The hierarchy descends from the general to the more particular, until a level of operational sub-criteria is reached, against which the decision alternatives of the lowest level of the hierarchy can be evaluated. The hierarchical structure of the basic AHP allows dependencies among elements to be only between the levels of the hierarchy, and the only possible direction of impact is towards the top of the hierarchy.

This eliminates the possibility of including feedback relations in the model. Also the elements of a given level are assumed to be mutually independent (Hamalainen and Seppalainen, 1986).

In this research, ANP is appropriate for solving problems that can be structured into network-like decision models, which will be discussed in detail in the next section. The AHP method is appropriate for hierarchical decision problems.

7.3.2 Analytical Network Process

ANP is an attractive multi-criteria decision making tool because it allows for the consideration of interdependencies among and between levels of attributes.

ANP involves representing relationships hierarchically but does not require a strict hierarchical structure as does AHP. The ANP technique allows for more complex interrelationships among the decision levels and attributes. ANP models problems of systems in which the relationships between the levels are not easily represented as higher or lower, controlling or subordinate. These systems are known as ‘systems-with-feedback’ which refers to systems where a level may both dominate and be dominated, directly or indirectly, by other decision attributes and levels (Saaty, 1996).

The work on systems-with-feedback is extended to show how to study inner and outer dependence with feedback. Outer dependence is the dependence that exists between components but in a way that allows for feedback circuits. Inner dependence is the interdependence within a component combined with feedback between components

(Saaty, 1987). The ANP technique has had a few applications as described in the research literature which are going to be shown later (section 7.4).

Most of the modeling and decision frameworks in AHP and ANP can be described graphically. For example, in the AHP approach there are one-way hierarchical arcs that show a dominance or control of one level of attributes over another set of sub-components or attributes. In the ANP approach, with the allowance of interdependencies occurring among attributes and attribute levels, the graphical representation may include two way arrows (or arcs) between levels. A looped arc is used to show the interdependency relationships that occur within the same level of analysis. The directions of the arcs signify dependence; arcs originate from an attribute to other attributes that may influence it.

As mentioned, the elements of the ANP system may interact along many paths. For the measurement of priorities to be meaningful, uniformity is necessary when considering all the paths of the network. The supermatrix that is derived in the ANP approach helps to evaluate this framework.

Many decision problems cannot be structured hierarchically where the interaction of higher level elements with lower level elements and their dependency needs to be taken into account. ANP provides a solution for problems which cannot be structured hierarchically. Not only does the importance of the criteria determine the importance of the alternatives, as in a hierarchy, the importance of the alternatives themselves determine the importance of the criteria (Saaty, 1986). Therefore, many problems can be modeled using a diagram called a network, as presented in figure (7-2).

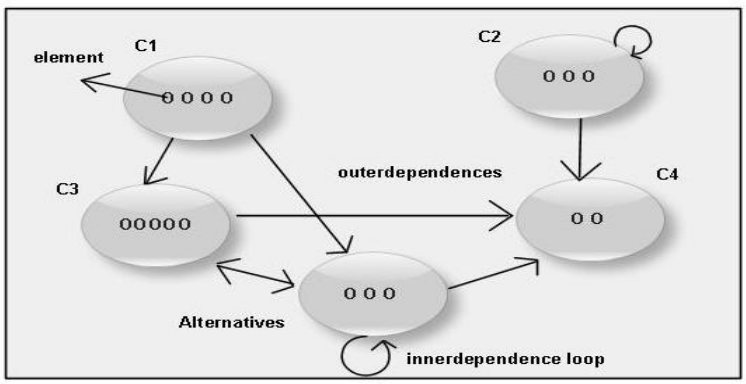

Figure 7-2 Simple Network Model

Network models do not have to show a hierarchical structure, which means they do not have to be linear from the top to the bottom. In fact ANP uses a network for which it is not necessary to specify levels, as in a hierarchy (Saaty, 1999); therefore the term level in AHP is replaced by the term cluster in ANP. The network model has cycles connecting its clusters of elements and loops that connect a cluster to itself. This kind of model is called systems-with-feedback (Meade and Rogers, 1997). In practice, many decision problems involve feedback.

Some applications for ANP appear in the literature as shown in table (7-1) and these will be discussed in the next section

7.4 Analytic Network Process Applications

Table 7-1 ANP Applications

	Application	Reference
1.	Organisational project alternatives for agile manufacturing process	Meade and Sarkis (1999)
2.	Location selection: a shopping mall illustration	Cheng et al. (2005)
3.	Project selection	Cheng and Heng (2005)
4.	Vendor selection decision	Bayazit (2006)
5.	Advertising media budget allocation decision	Coulter and Sarkis (2006)
6.	Valuation of urban industrial land	Aragones-Beltran et al. (2006)
7.	Assessment of dispatching rules for water fabrication	Lin et al. (2007)
8.	Resource allocation in transportation	Wey and Wu (2007)
9.	Selection of logistics service provider	Jharkharia and Shankar (2007)
10.	Selecting knowledge management strategies	Wu and Lee (2007)
11.	Performance management in construction	Isik et al. (2008)
12.	Municipal solid waste disposal options	Khan and Faisal (2008)

Table (7-1) summarises some of the ANP applications as they appear in the literature. ANP was used by Meade and Sarkis (1999) to make an analysis of organisational project alternatives to be used in agile manufacturing processes, in effect making use of an analytical network approach. In their research Cheng et al. (2005) demonstrated how ANP was used to find the optimum site for a shopping mall. ANP is an inventive and vigorous MCDM method which is able to produce an analytic structure that can be used to solve problems relating to decisions in society and government as well as to corporate decisions. It was the belief of Cheng et al. (2005) that ANP was a suitable instrument to use to make the decision as to where to locate a shopping mall and this

particular example demonstrated that. The findings gained from the use of the two methods were compared in order to make clear the differences between ANP and AHP and the result of this suggested strongly that ANP is able to provide a powerful instrument for solving decision making problems if independent relationships strongly impact within the decision model.

In the case of a complex construction model Cheng and Heng (2005) found that ANP was useful when dealing with relationships within an MCDM model where they are interdependent. They employed an example in order to make clear, by the use of a five-level project selection model, how to empirically prioritise a set of projects. To this end they had a group of construction professionals working with a local developer of medium size fill in a questionnaire; subsequently the results were computed in order to prioritise the possible projects. The work that they undertook is of use to both those working within industry and to researchers. Those working in industry have the opportunity to make use of the weighted criteria in order to select a project directly from it or else they can use the ANP method in order to prioritise their own existing set of selection criteria.

An understanding of how ANP can be used through MCDM methodology in order to make an evaluation of problems with a choice of supplier which have many areas that can be assessed qualitatively and quantitatively, was given by Bayazit (2006). In this study the proposal is made that an ANP model should be used in order to evaluate the process of supplier selection and this should provide a useful tool for managers. According to his findings it was possible to use ANP as a tool for decision analysis to find a solution to the choice of supplier where multi-criteria were involved and where the problems included interdependencies.

A complete model enabling budget allocation and choice of media using ANP was developed and also tested by Coulter and Sarkis (2006). Their findings were that it is possible to use ANP to find a solution to difficult decision making problems by bringing together various measures, i.e. qualitative/intangible and quantitative/tangible, to arrive at a single overall score in order to rank the various decision possibilities. The model that was arrived at from this can be used effectively both by those who are very experienced and those whose experience is limited. In

their study they showed how their model could be used for the distribution of media dollars in the airline business and also in financial services.

Aragones-Beltran et al. (2006) found two areas in which ANP could be utilised, one being to find a solution to some of the problems associated with traditional methods of asset evaluation and the other being to increase the scope of existing approaches; this new approach has been used in a real case study of a recreational park in Valencia (Spain) through the use of three different models. The results show the suitability of the ANP methodology and demonstrate that the more information a model uses, the more accurate the solution it arrives at will be.

Lin et al. (2007) used the ANP method to look at the relationships between a number of performance indicators as well as the relationship between performance indicators and dispatching rules. They created a dispatching model which was based on the characteristics of all onsite production resources, for example the use of bottleneck machines. It was proposed that the ANP dispatching assessment model used in their research would have the capacity to provide an analytic framework that would enable those making decisions in the future to appraise production dispatching models dealing with multiple production indicators.

Wey and Wu (2007) make the suggestion that there should be a better method of project selection to deal with transport infrastructure. This should take into account the interdependencies existing between criteria used to evaluate and candidate projects when using ANP within a zero-one goal programming model. Although various projections are a part of goal programming in order to provide the best solution to a problem, Wey and Wu (2007) suggest that its main disadvantage is that goals and priorities must be made clear by those making the decision and must be based on existing knowledge and they suggest that group discussion would be a way to deal with this problem.

An all-inclusive methodology has been suggested by Jharkharia and Shankar (2007) for the location of a logistic service provider and this is made up of two parts, these being a preliminary screening of those providers that are available and a final choice based on ANP. The ANP model was constructed after having identified those criteria that are necessary to make a choice of a provider and the subsequent use of ANP to

make the final choice was shown by using an illustrative example. The conclusion that was drawn from this was that the most important determinant for the final choice was the compatibility between the user and the providing company. This approach also made it possible for the decision makers to have a fuller understanding of how the relevant characteristics of the decision making were inter-related and this had the potential to allow a more reliable ultimate decision.

It is critical if knowledge management is to be successfully put in place, that companies should be better able to assess and choose an appropriate strategy for knowledge management before using it. However, in order to do this a type of MCDM problem arises where many complex issues need to be considered. Wu and Lee (2007) have developed through their work an efficient method based on ANP to assist companies needing in assessment and selection of strategies for knowledge management. An empirical study also exists that demonstrates how such a method should be applied.

In the research of Isik et al. (2008) a conceptual performance measurement framework was put in place that was able to take into consideration company level issues such as objectives strategies and resources as well as factors existing at a project level, for instance both opportunities and risks, and also aspects at the level of the market, such as competition and demand. In order for a conceptual framework to be utilised to measure performance a methodology that incorporates both quantitative and qualitative aspects as well as the relationships between the two should be used. ANP provides the best suited techniques where interaction between the various aspects of a system provides a network structure.

An evaluation method presented by Khan and Faisal (2008) has the capacity to help decision makers within a local civic body to decide on priorities and choose the most efficient method to dispose of municipal solid waste. Their method makes use of a hierarchical network decision structure and applies the supermatrix approach of ANP in order to measure which is the best method of waste disposal though the use of value methods representing the contribution of the various stakeholders.

7.5 Advantages and Disadvantages of ANP over AHP

Before use is made of ANP its advantages and disadvantages need to be examined in relation to this research. According to Ravi et al. (2005) the advantages and disadvantages of ANP can be summed up as in the following:

1. The rank reversal problem of ANP has been addressed so that it is more accurate than AHP when used as an instrument to support decisions in complex situations. Although both ANP and AHP have as their basis preferences that have been supplied by the user, among the other weights and factors to be taken into account is that they are different from each other in both the number and the types of the pairwise comparisons that they make as well as in the way that they actually calculate the utility weights (Cheng and Li, 2004).
2. ANP is a method that takes into account all relevant criteria, including the intangible as well as the tangible aspects which may all have some influence on the process of decision making (Saaty, 1996).
3. AHP makes use of a framework for making decisions that assumes that the hierarchical relationship among the decision levels is one directional, while ANP makes provision for more complex relationships and characteristics since a strictly hierarchical structure is not necessary to its function.
4. Where problems related to decision making exist, it is crucial to include among the criteria interdependent relationships because this manifestation of interdependence is likely to exist in problems in the real world. The ANP methodology allows for this consideration to be included among the criteria and between its different levels and it is this which makes ANP such an efficient instrument for multi-criteria decision-making and superior to AHP which is not able to deal with interdependencies between various enablers and between criteria and sub-criteria (Agarwal and Shankar, 2003).
5. The ANP method can confer benefits in the consideration of qualitative as well as quantitative characteristics and these need to be considered as well as interdependent relationships that are non-linear (Meade and Sarkis, 1999).
6. Only ANP is able to supply synthetic scores which give an indication of the relative ranking of the various alternatives that the decision maker is considering.

7.6 Disadvantages of ANP

1. ANP relies on the fact that the knowledge, judgement and principles of those who make decisions have an equal value at least to the data they use. This means that findings may be based on judgements that are essentially subjective as the thought processes of the decision makers may rely heavily on intuition (Rebstock and Kaula, 1996).
2. Compared with AHP, ANP needs a higher level of calculations and of extra pair-wise comparison matrices which means that it is vital to carefully track matrices and pair-wise comparisons of attributes.
3. This means that ANP must make use of a statistical level that most users find complex so that the whole process becomes a complicated one (Boer et al., 2001).

It is important that while taking a positive approach to those aspects of ANP that are useful for this research, its drawbacks are also considered. Firstly it is important to arrange an experienced team with expertise in the relevant area, secondly there has to be enough time and manpower for an adequate collection of the data, and thirdly use must be made of specialist instruments such as ‘Expert Choice’ and ‘Super Decision’ to make the calculations and to form the pair-wise comparison matrices.

7.7 ANP Methodology

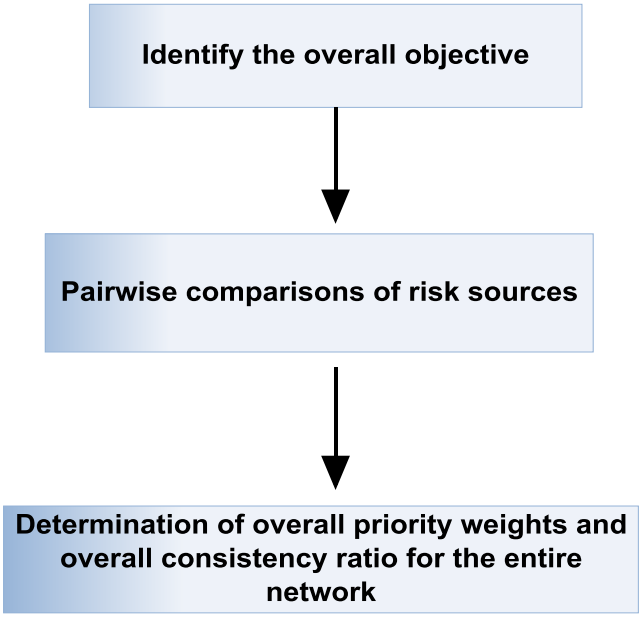

Figure 7-3 Overview of Risk Decision Process using ANP

The ANP incorporates both qualitative and quantitative approaches to a decision problem. The three major steps for the qualitative component which are summarised in Fig (7-3) above are described below:

1. Identification of the decision problem, in this case "Measuring the risk source importance for VO collaboration".
2. Ensuring that the decision problem can be solved by ANP. The use of ANP is appropriate to solve decision problems with a network structure. Problems with a simple hierarchical model can be solved by AHP.
3. Determining who should be responsible for making the decision.

The following describes the five major steps for the quantitative component:

1. Set up a quantitative questionnaire for collecting data from suitable respondent. Saaty (1996) suggests the use of a nine-point priority scale and pair-wise comparison.
2. Estimate the relative importance between the two elements (when pair-wise comparison is used) in each matrix and calculate the eigenvector of each of the developed matrices. Refer to the existing literature having suggested the

necessary algorithms for calculating the eigenvector of each matrix, such as Saaty (1980) and Cheng and Li (2001).

3. Measure the inconsistency of each of the matrices (when pair-wise comparison is used) by employing the consistency ratio (CR). The CR simply reflects the consistency of the pair-wise judgements. For example, judgements should be transitive in the sense that if A is considered more important than B, and B more important than C, then A should be more important than C. If, however, the user rates A as being as important as C or C as being more important than A, the comparisons are inconsistent and the user should revisit the assessment. Refer to the existing literature having suggested the necessary algorithms to calculate CR, such as Saaty (1996) and Cheng and Li (2001). Alternatively, commercial software packages that compute CRs and eigenvectors are available (Super Decisions Software and Expert Choice for Windows). Saaty (1994) sets three acceptable levels for CR (i.e. 0.05 for 3 by 3 matrix, 0.08 for 4 by 4 matrix, and 0.1 for other matrices). Matrices that are inconsistent should be excluded or rated by the raters.
4. Place the eigenvectors of the individual matrices (also known as submatrices) to form the supermatrix (Saaty 1996).
5. Ensure the supermatrix is column stochastic and raise the supermatrix to high power until the weights have been converged and remain stable (Sarkis, 2002). For the purpose of mathematical computation of matrices. A commercial software tool, Super Decisions has been used. The Super Decisions software implements the ANP developed by Saaty. The program was written by the ANP Team, working for the Creative Decisions Foundation and is appropriate to solve decision problems with a network model (Saaty, 2003).

7.8 Procedures for Model Development

The ANP model requires the relationships to be determined between the various elements both within and across levels (the decision network). The decision network developed for this study has both interdependent and hierarchical relationships within it. Our goal is to determine the importance of risk sources in the VO collaboration and to be able to choose the less risky SME to collaborate with from the alternatives, if applicable.

The network relationships (among the clusters of elements) occur at the risk source level, where various sources can influence each other. The influence of each of the risks on the objective and on each of the other risks was accomplished using thirteen pairwise comparison matrices, which were then integrated into a supermatrix.

The model was tested with 45 participants who responded the questionnaire. An example of a survey question is as follows: "How much more important is lack of trust than an inadequate collaboration agreement?" See table (7-2) for the pair-wise comparison scale.

Table 7-2 Pair-wise Comparison Scale

Intensity of importance	Verbal meaning for risk source evaluation
1	Equally importance of both sources
3	Weak importance of one source over another
5	Essential or strong importance of one source over another
7	Demonstrated importance of one source over another
9	Absolute importance of one source over another

The pair-wise comparison information that was elicited from each of the respondents was obtained to determine the relative importance of weights using Super Decisions.

Conventionally, risk analysis is performed at the collaboration phases. Hence, the risk analysis should show the effects of the risks in collaboration (in terms of time, cost, quality goals and total failure of the collaboration).

From the respondents to the ANP questionnaire the risk sources comparison matrix has been found as shown in table (7-3).

Table 7-3 Risk Comparison Matrix

	R1	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**R_7**	**R_8**	**R_9**	**R_{10}**	**R_{11}**	**R_{12}**	**R_{13}**
1. Lack of trust between partners	1	5/1	7/1	7/1	9/1	9/1	3/1	5/1	3/1	5/1	9/1	3/1	9/1
2. Inadequate collaboration agreement	1/5	1	3/1	5/1	5/1	1/3	7/1	9/1	1/3	1	7/1	1/5	9/1
3. Heterogeneity of partners	1/7	1/3	1	3/1	3/1	1/5	7/1	9/1	1/5	1/3	5/1	1/7	9/1
4. Ontology differences	1/7	1/5	1/3	1	3/1	1/7	7/1	9/1	1/7	1/5	5/1	1/7	9/1
5. Structure and design	1/9	1/5	1/3	1/3	1	1/7	5/1	7/1	1/7	1/5	3/1	1/9	7/1
6. Loss of communication	1/9	3/1	5/1	7/1	7/1	1	9/1	9/1	1	3/1	9/1	1/3	9/1
7. Culture differences	1/3	1/7	1/7	1/7	1/5	1/9	1	3/1	1/9	1/7	1/3	1/9	3/1
8. Bidding for several VOs at the same time	1/5	1/9	1/9	1/9	1/7	1/9	1/3	1	1/9	1/7	1/5	1/9	1
9. Lack of information sharing	1/3	3/1	5/1	7/1	7/1	1	9/1	9/1	1	3/1	9/1	1/3	9/1
10. Lack of top management commitment	1/5	1	3/1	5/1	5/1	1/3	7/1	7/1	1/3	1	7/1	1/5	9/1
11. Lack of knowledge about risks	1/9	1/7	1/5	1/5	1/3	1/9	3/1	5/1	1/9	1/7	1	1/9	5/1
12. Wrong partner/s selection	1/3	5/1	7/1	7/1	9/1	3/1	9/1	9/1	3/1	5/1	9/1	1	9/1
13. Geographic location	1/9	1/9	1/9	1/9	1/7	1/9	1/3	1	1/9	1/9	1/5	1/9	1

7.8.1 Enhanced ANP for risk calculation

In general, ANP reduces complex decisions to a series of one-to-one comparisons, and then synthesises results. In this research, ANP is applied to calculate the weights, a factor indicating how important the particular risk is. First, comparisons are made between the thirteen risk sources “lack of trust between partners”, “lack of top management commitment” “Inadequate collaboration agreement”, “heterogeneity of partners”, “ontology differences”, “structure and design” , “loss of communication ”, “culture differences”, “ bidding for several VOs”, “information sharing” , “lack of knowledge about risks”, “wrong partner/s selection” and “ geographic location” so that $Wi(i = 1, \dots, n\ of\ risk\ sources)$ are calculated.

7.8.2 Pair-wise Comparison and Calculation

The interactions between the involved elements are measured through comparisons which are made with respect to the "influencing element" instead of the higher level element. The influence of elements is measured using the pair-wise comparison method where two elements at a time are compared with respect to a control element. This method is used for eliciting the decision makers' preferences more effectively.

The question asked in a hierarchy form while doing comparisons should be: "Which of two elements has more influence with respect to a certain element in the above level?" while, in a network form (ANP), the relation is not limited to a higher level but to the influence element, which would be: "Which of two elements has more influence with respect to the other element?"

As the questionnaire was designed using the nine-point scale, score 1 represents equal preference between the two elements, 9 represents extremely important with the row element being dominant over the column element, while 1/9 represents extremely important with the column element being dominant over the row element. A reciprocal score is given to the reverse element as a reverse value in the matrix comparison. That is, if aij is a matrix value assigned to the relationship of factor i to factor j, then aji is equal to $1/aij$ (or $aji \times aji = 1$). The answer to these pair-wise questions will help complete the pair-wise comparison matrix.

Based on the questionnaire responses the pair-wise comparison result is shown in table (7-3). From those 78 pair-wise comparisons, the eigenvector is calculated. The resulting matrix of pair-wise comparisons from comparing the criteria with respect to the goal is shown in table (7-5); Saaty (2001) proposes several algorithms for approximating w. Like the AHP, pair-wise comparisons in the ANP are within the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with risks sources being compared by solving the following formula:

$$AW = \lambda maxW$$

Where λmax is the largest eigenvalue of pair-wise comparison matrix A. The relative importance weights (w) for risks sources as well as the relative importance weights

from the network portion of the decision hierarchy (i.e., representing the relationships among the risks sources) were then introduced into a supermatrix.

In this research, the following three-step procedure is utilised to synthesise priorities (Meade and Presley, 2002).

1. Sum the values in each column in the pair-wise comparison matrix.
2. Divide each element in a column by the sum of its respective column. The resulting matrix is then called the normalized pair-wise comparison matrix.
3. Sum the elements in each row of the normalised pair-wise comparison matrix, and divide the sum by the *n* elements in the row. These final values provide an estimate of relative priorities for compared elements with respect to the upper level criterion. Priority vectors must be derived for all comparison matrices.

7.8.3 Supermatrix Formation

The supermatrix concept is similar to the Markov chain process (Saaty, 2001; 2006). To acquire global priorities in a system with interdependent influences, local priority vectors are entered in the appropriate columns of a matrix, which is known as a supermatrix. Consequently, a supermatrix is actually a partitioned matrix, in which each matrix segment represents a relationship between two nodes (components or clusters) in a system (Meade and Sarkis, 1999). Let the components of a decision system be C_k, $k = 1, 2, \ldots, N$, which has n_k elements denoted as $e_{k1}, e_{k2}, \ldots, e_{kn}$. The local priority vectors obtained are grouped and allocated to the appropriate positions in a super-matrix according to the flow of influence from one component to another, or from a component to itself as in a loop. A standard form of a supermatrix is as in the following equation (Saaty, 2001).

$$
W = \begin{array}{c}
 \\
 \\
C_1 \\
 \\
 \\
C_k \\
 \\
 \\
C_N \\

\end{array}
\begin{array}{c}
\begin{array}{cccccccccc}
C_1 & & \cdots & & C_k & & \cdots & & C_N & \\
e_{11} & \cdots & e_{1n_1} & \cdots & e_{k1} & \cdots & e_{kn_k} & \cdots & e_{N1} & \cdots \quad e_{Nn_N}
\end{array} \\
\begin{bmatrix}
W_{11} & \cdots & W_{1k} & \cdots & W_{1N} \\
\vdots & & \vdots & \ddots & \vdots \\
W_{k1} & \cdots & W_{kk} & \cdots & W_{kN} \\
\vdots & & \vdots & \ddots & \vdots \\
W_{N1} & \cdots & W_{Nk} & \cdots & W_{NN}
\end{bmatrix}
\end{array},
$$

As an example, a supermatrix representation in a hierarchy with three is as follows (Saaty, 2001):

$$W_h = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & 0 & 0 \\ 0 & W_{32} & I \end{bmatrix}$$

where W_{21} is a vector representing the impact of the goal on the criteria, W_{32} is a matrix representing the impact of criteria on each alternatives, I is an identity matrix, and zeros correspond to elements that have no impact.

For this example, when criteria are interrelated the hierarchy is replaced by a network. The (2, 2) entry of Wn given by W_{22} indicates interdependency, and the supermatrix would be (Saaty, 2001)

$$W_n = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{bmatrix}$$

Notably, any zero in the supermatrix can be replaced by a matrix when an interrelationship exists between elements in a component or between two components. As an interdependence typically exists among clusters in a network, the sum of columns in a supermatrix usually is typically greater than > 1. The supermatrix must first be transformed to make it stochastic, in other words each column in a matrix sums to unity. In other words, the row components with nonzero entries for the blocks in a given column block are compared according to their impact on the component of that column block (Saaty, 2001). An eigenvector can be obtained

for a pair-wise comparison matrix of the row components with respect to the column component. This process yields an eigenvector for each column block. The first entry of the respective eigenvector for each column block is multiplied by all elements in the first block of that column, the second entry is multiplied by all elements in the second block of that column this process continues. In this manner, the block in each column of the supermatrix is weighted and the result is known as a weighted supermatrix, which is stochastic.

Raising a matrix to powers generates the long-term relative influences each element has on each other element. To attain a convergence on importance weights, the weighted supermatrix is raised to the power of $2k + 1$ where k is an arbitrarily large number. This new matrix is called a limit supermatrix (Saaty, 2001). A limit supermatrix has the same form as a weighted supermatrix; however, all the columns in the limit supermatrix are the same. By normalising each block of this supermatrix, the final priorities of all elements in the matrix can be derived.

All the calculation can be calculated using Super Decisions software, written by the ANP Team. Data of the completed questionnaire are entered into the Super Decision software to get the normalised eigenvectors, *C.R.*, weighted supermatrix, and limiting supermatrix.

Table 7-4 Normalised eigenvector

R1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}
0.3003	0.2599	0.2172	0.1632	0.1807	0.5770	0.0443	0.0602	0.3126	0.2594	0.1390	0.5078	0.1011
0.0601	0.0520	0.0931	0.1166	0.1004	0.0214	0.1034	0.1084	0.0347	0.0519	0.1081	0.0339	0.1011
0.0429	0.0173	0.0310	0.0699	0.0602	0.0128	0.1034	0.1084	0.0208	0.0173	0.0772	0.0242	0.1011
0.0429	0.0104	0.0103	0.0233	0.0602	0.0092	0.1034	0.1084	0.0149	0.0104	0.0772	0.0242	0.1011
0.0334	0.0104	0.0103	0.0078	0.0201	0.0092	0.0739	0.0843	0.0149	0.0104	0.0463	0.0188	0.0787
0.0334	0.1559	0.1551	0.1632	0.1405	0.0641	0.1330	0.1084	0.1042	0.1557	0.1390	0.0564	0.1011
0.1001	0.0074	0.0044	0.0033	0.0040	0.0071	0.0148	0.0361	0.0116	0.0074	0.0051	0.0188	0.0337
0.0601	0.0058	0.0034	0.0026	0.0029	0.0071	0.0049	0.0120	0.0116	0.0074	0.0031	0.0188	0.0112
0.1001	0.1559	0.1551	0.1632	0.1405	0.0641	0.1330	0.1084	0.1042	0.1557	0.1390	0.0564	0.1011
0.0601	0.0520	0.0931	0.1166	0.1004	0.0214	0.1034	0.0843	0.0347	0.0519	0.1081	0.0339	0.1011
0.0334	0.0074	0.0062	0.0047	0.0067	0.0071	0.0443	0.0602	0.0116	0.0074	0.0154	0.0188	0.0562
0.1001	0.2599	0.2172	0.1632	0.1807	0.1923	0.1330	0.1084	0.3126	0.2594	0.1390	0.1693	0.1011
0.0334	0.0058	0.0034	0.0026	0.0029	0.0071	0.0049	0.0120	0.0116	0.0058	0.0031	0.0188	0.0112

Table 7-5 Risk Sources Weights

Risk source	Weight n=13	Weight n=1	Percentage weight
1. Lack of trust between partners	3.1227	0.2402	24.02%
2. Inadequate collaboration agreement	0.9850	0.0758	7.58%
3. Heterogeneity of partners	0.6868	0.0528	5.28%
4. Ontology differences	0.5960	0.0458	4.58%
5. Structure and design	0.4184	0.0322	3.22%
6. Loss of communication	1.5101	0.1162	11.62%
7. Culture differences	0.2540	0.0195	1.95%
8. Bidding for several VOs at the same time	0.1510	0.0116	1.16%
9.Lack of information sharing	1.5768	0.1213	12.13%
10. Lack of top management commitment	0.9609	0.0739	7.39%
11. Lack of knowledge about risks	0.2795	0.0215	2.15%
12. Wrong partner/s selection	2.3362	0.1797	17.97%
13. Geographic location	0.1226	0.0094	0.94%
	13.0000	1.0000	100%

The results of ANP are shown in table (7-5) and $CR = 0.09$ which is less than 0.10, the acceptable consistency ratio for ANP.

7.8.4 Analysis of results

7.8.4.1 Importance of risks sources

It is important to establish the relative importance of risk sources subsequent to subjective evaluation of them on a nine point scale (table 7-3) since this provides a more reliable result than when all the criteria or the alternatives are evaluated at the same time. In all 45 pair-wise comparisons were made. The relative importance of each source of risk as indicated by the weight given to each, is given in table (7-5). An interpretation of the weights, which all add up to one can be understood in the following way: in a situation where a enterprise is able to devote 100 minutes to a consideration of collaboration sources of risk , then approximately 24 minutes of this time should be given to those areas that relate to lack of trust and the uncertainty that is intrinsic to this source of risk with an additional 18 minutes being spent on a

consideration of wrong partner/s selection, 12 minutes on the sharing of information with roughly the same amount of time being spent on loss of communication. This leaves only 34 minutes to be given to the consideration of other sources of risk which is an indication of their relative lack of importance compared with the two major sources of risk (Schoenherra et. al., 2008; Wu et. al., 2006).

7.8.5 Conclusion and Discussion

In practice ANP was found to be a potent and suitable instrument to deal with the problem of decision making that the venture confronted and the result of this was a significant level of confidence to implement the solutions that had been suggested. ANP is also able to integrate qualitative criteria which gives it added strength, as does its capacity to factor in the uncertainty that is inherent in decision making. Although it would have been possible to come to a solution simply by examining the sources of risk and then arriving at what seemed to be the best solution without making use of ANP, the number of sources of risk that are involved and the alternatives that exist mean that this approach might well have thrown up a result which was tending towards the random. It is relatively easy to come to a decision when only two or three risk sources have to be considered, but it is much more difficult to come to a decision when 13 risk sources are involved. In such circumstances it would be probable that some of the risk sources that are lower weighted would have to be ignored, that is a non-ANP approach would have to be adopted simply to make the process of decision making viable. For this reason the use of ANP is definitely to be recommended not only when making decisions related to collaboration but also when there is any doubt regarding a MCDM problem. As well as allowing there to be more confidence in the decision that is reached, ANP also provides a very good way for any enterprise to validate the decision that they have made.

The process of the research has, in this case, provided an approach that is both thorough and methodical so that it was possible for there to be confidence in the decision that was finally reached. During the research process the thorough literature review revealed a comprehensive list of risk sources in VO as did the expert questionnaire which meant that it was possible to feel confident with the final decision. Although for other ventures it is likely to be the case that sources of risk and their weights may differ, the method that has been used to decide them in this case, is

one that is recommended. It is also the case that the particular risk sources that have been identified will be able to be used as a point at which to begin for other ventures seeking to explore the risks that are relevant to their particular circumstances. This means that that there is a much firmer foundation on which to base a decision rather than simply considering all the possible risks and alternatives. The use of ANP ensures that no relevant source of risk is overlooked and that all the pertinent issues are taken into consideration. All this ensures that the research is able to provide a template as well as being a source of encouragement for SMEs looking to join a VO.

Nonetheless, the assessment of risk is a process that is constantly evolving so that it is possible to deal with changes occurring in the environment. Once the comparison matrices have been set up they can be re-examined so that alterations can easily be made to evaluations in response to changes that have taken place and for this reason ANP can be considered to be an outstanding tool. It is the case that some sources of risk may become less important or even completely disappear, while others increase in importance, and also fresh sources of risk, that did not previously exist, may have to be taken into consideration. Once a successful decision has been made no venture should consider that to be the end of the matter; rather they should be constantly vigilant so that they can identify new risks that may emerge.

Finally, setting up this method for evaluating weights has helped with the task of prioritising and defining both the part played by sources of risk and their relative importance and this helps in the making of two decisions: deciding which sources of risk are the most important and setting up the priorities for risk management.

Chapter 8 Case Study

8.1 Introduction

This chapter aims to develop a deeper understanding of the main constructs of risk sources in a virtual organisation, especially their dependencies and weights. The review of the literature and early steps to develop a framework took place before this case study.

A case study method (Yin, 1994) has been used in this research to be able to explore the studied phenomena in more depth. The case study method is especially suited in situations where the purpose is to gain a deeper understanding of the research subject. Data was gathered mainly through in-depth on site structured interviews with two managers representing their enterprises, access to some limited documentation and visits to the different departments of the enterprise.

The purpose of this study is to provide an understanding of risk sources in the context of virtual organisation. In addition, risk sources are assessed and related to the level of virtual organisation collaboration. Although this study focuses on small and medium enterprises, it is expected to provide a holistic understanding of risks and their implications for the whole of VO, with wider applicability.

The single case study proved to be an effective methodological approach for conducting this research and as a consequence provided a rich insight into the phenomena of risks in a VO. The case was exploratory as there have been no previous studies of risks conducted in a VO which have focused on a single enterprise, which was required here because of the sensitivity of the research subject. The researcher embraced a somewhat ‘native’ approach, blending into the enterprise ‘as one of them’ rather than being seen as an investigator. This was an advantage, as respondents were less reluctant to share information, and as trust between the researcher and respondents developed so did the access to sensitive information increase.

This collaboration risk management case study has been undertaken with Control 2K Ltd as they have a great deal of collaboration experience. To protect enterprise

interests, confidential or sensitive enterprise information has been filtered. In addition, information related to sensitive collaboration risks has been omitted.

8.2 Case study Research and Research Method

Based on a thorough literature review and experts' opinions 13 risk sources have been identified in the VO collaboration. Through the second stage of the study based on a questionnaire sent to the INTEROP-VLab members, the risk sources have been related in direct and indirect relationships using the ISM (Interpretive Structural Modeling) technique to reach a model as shown in figure (6-6). The purpose of this study is to reach an in-depth understanding of these relationships and how strong are they.

Also based on the questionnaire sent to the same experts in INTEROP-VLab the weights (relative importance) of these risk sources have been analysed using the ANP (Analytic Network Process) technique (table 7-5). This case study examines further for those weights and probabilities associated with particular risk sources for partners.

Although a case research is often related to qualitative research only, multiple data collection methods allow the combination of both quantitative as well as qualitative aspects. While qualitative data is useful for understanding, quantitative surveys can strengthen its relationship to existing theory (Eisendhardt, 1989).

8.2.1 Case Study Research

The term "case study" has multiple meanings. It can be used to describe a unit of analysis (e.g. a case study of a particular organisation) or to describe a research method. The discussion here concerns the use of the case study as a research method. Although there are numerous definitions, Yin (1994) defines the scope of a case study as an empirical inquiry that 'investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are clearly not evident, and in which multiple sources of evidence are used'. Clearly, the case study research method is particularly well-suited to our research, since the object of our discipline is the study of virtual organisations collaboration, and "interest has shifted to organisational rather than technical issues" (Benbasat et al. 1987).

To explore these issues further Control 2K was chosen as the case example. The case study approach was adopted for the empirical investigation of this research as it is useful for exploring areas where theory is still developing. It enables the researcher to gain in-depth understanding of a situation which is difficult to investigate using other techniques such as surveys. It is useful for examining questions of how and why so that new insights and knowledge may be gained. Also an interview allows the researcher to probe more deeply into the interviewee's thoughts and ideas and to collect more details than is possible with a survey.

In addition to Yin (1994) a previous definition of a case study was given by Eisendhardt (1989), who maintained that the case study is a research strategy that focuses on understanding the dynamics present within single settings. It is particularly appropriate for those problems in which research and theory are at their early, formative stages (Cepeda and Martin, 2005).

Case study research includes single or multiple cases and numerous levels of analysis. It makes use of qualitative data or quantitative data or both simultaneously (Yin, 1994). The key feature of this approach is not method or data but the emphasis on understanding processes as they occur in their context (Amaratunga, 2002). The major advantages of case research are (Cepeda and Martin, 2005):

- The phenomenon can be studied in its natural setting and meaningful, relevant theory generated from the understanding gained through observing actual practice.
- The case method allows the questions of why, what and how, to be answered giving a relatively full understanding of the nature and complexity of the complete phenomenon.
- The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon little understood.
- Unlike other research methods, which often aim at statistical correlations with less regard for the underlying explanations, case research is capable of discovering true causal relationships.

Finding such causal relationships should be the objective of the researcher in conducting case research (Hillebrand et al., 2001). These questions deal with operational links that may need to be traced over time, rather than relying on mere

frequencies or incidence (Wouters, 2004). However, the method also has some disadvantages (Simon et al., 1996):

- Conclusions may be statistically limited in that often only a handful of cases are used to generalise in relation to certain research questions.
- Research 'purists' (or quantitative advocates) may tend to see case studies as lacking in academic rigour.
- Cases capture the experience of an organisation only at a particular period in time and therefore they become dated with the passage of time.

Case studies can incorporate several different methods, including participant observation, structured or unstructured interviews and examination of documentary material (Simon et al., 1996).

8.2.2 Single Case Study

Due to VO risks being so intrinsically dynamic, practically oriented case study research (Eisenhardt, 1989; Yin, 1994) is often used as a methodological choice.

Eisendhardt's (1989) framework starts with the need to select appropriate cases. On the one hand, the fewer the case studies the greater the opportunity for in-depth insights; on the other hand using only a small number of cases inevitably has its limitations including the risks of misjudging data (Voss et al., 2002; Rowley, 2002). However, the selection of cases has to be related to the objective of the research (Yin, 1994).

Case study research frequently applies qualitative research approaches, but occasionally it combines both qualitative and quantitative approaches. It is often emphasised that deeper understanding of the phenomenon compensates for the lack of statistical generalisation. It is also argued that research with large samples does not adequately understand the true problems underpinning the research objects (Hilmola et al., 2005).

As described above, the case study research method is used when phenomena and context do not have exact boundaries (Yin, 1981; 1994; Eisenhardt, 1989). This is why iterative triangulation using multiple sources such as a literature review, case evidence and intuition is often applied in case research. The research question often

changes during the research work, partly because of this iterative nature. Description of completed work usually combines both quantitative and qualitative information, using comparisons within and between the cases under scrutiny. Most often qualitative research in supply chain or virtual organisation research uses interviews (Hilmola et al., 2005).

Eisenhardt (1989) suggests that four to ten cases are needed for generating theory: he argues that fewer than four cases do not give the potential to create complex theory and with more than ten cases it is difficult to manage the voluminous data. However, Yin (1981; 1994), Dyer and Wilkins (1991), Meredith (1998) and Hill et al. (1999) emphasise that the sample size could be single as in this research. Furthermore Dyer and Wilkins (1991) argue that the key issue is not the number of cases, the time spent in the field or the number of pages. The most important thing is that the researcher understands and describes the context clearly for readers and that she/he is able to generate theories from it.

In Hilmola's et al. (2005) comprehensive study they found that in 55 published articles dealing with supply chain management research using case studies, 30 articles based their work on a single case study. Nearly half of the articles concentrated on the operations of individual companies instead of supply chains whereas all of these articles declare themselves to be dealing with supply chain issues. Mostly these case studies comprise a single case examining supply chain issues from a single supply chain member's point of view.

8.3 Interview

Personal interviews should reveal individual perception of participation in a network, while comparative and objective answers were expected from the questionnaire. The author believes that talking to a sample from the participants in VO, and asking some deep and detailed questions will allow the most interesting evaluation of this research.

The interviews should give insights into individual experience and opinions on the VO in general which also have relevance to the relations between risk sources and their weights.

Prior to the interview, the selected respondents were briefed on the nature of the project by email, preparing them for what to expect in the interview. At the beginning of the interview, the first task was to introduce the research by explaining the objectives and briefly describing the previous work. The interview lasted for about 5 hours. Data was collected using a digital recorder and transcripts were made. The data was qualitative in nature.

In this research the structured interview was used which is a standardised set of questions. Even doing a study with a pre- structured interview, it would have been possible to modify the interview plan, if experience suggested that the topic or the approach was wrong. Pre-structured instruments can and usually should be revised.

A case study is not a survey, where reliability relies crucially on the characteristics of the data collection instruments. The case study relies on the trustworthiness of the human instrument (the researcher) rather than the data collection.

8.3.1 Case Study Investigator Skills

General skills needed by case study investigators (Robson, 2002):

1. Question asking; the need for an ‘enquiring mind’. The task here is to enquire why events appear to have happened or to be happening.
2. Good listening. Used in a general sense to include all observation and sensing, not simply via the ears. Also listening to what documents say. Taking in a substantial amount of information without bias; noting the exact words said; capturing mood and effective components; appreciating context.
3. Adaptability and flexibility. Case studies rarely end up exactly as planned.
4. Grasp of the issues; the need to interpret information during the study, not simply record it. Without a firm grasp of the issues (theoretical, policy etc...), the researcher may miss a clue, not see contradictions, or that further evidence is required.
5. Lack of bias. The preceding skills are negated if they are simply used to substantiate a preconceived position. The researcher should be open to contrary findings. During data collection, preliminary findings should be submitted to critical colleagues who are asked to offer alternative explanations as well as suggestions for data collection.

8.3.1.1 Interview Protocol

The aim of the protocol is to summarise the constructs used in the conceptual framework. In this case, the first part of the interview consisted of questions relating to business activities as well as the extent of the enterprise while there were also questions that allowed a more general discussion of what was specific to that sector. In the second part of the interview collaboration activities were covered. In particular this part of the interview was concerned with the reasons for embarking on the collaboration and the advantages and disadvantages arising from this together with the importance of the part played by trust in the collaboration. The third part concentrates on the sources of risk and its impacts and the tools of the collaboration and the fourth part explains the part played by the broker in VO. The fifth section covers relationships that can exist between the various sources of risk, and the final part compares the risk sources, using ANP as a base, that have been present over the previous three collaborations.

8.3.2 Data Transcription and Analysis

The interviews were recorded and transcribed in order to save the data. According to Flynn et al. (1990) transcription can be used to improve interviewing techniques and to detect the presence of leading questions on the part of the interviewer. They may also be used in conjunction with content analysis, e.g. the interview is recorded and a transcript is prepared. Content analysis then codifies the transcript, noting recurrent usage of a phrase or concept of interest and hypotheses may be developed or tested, based on the content analysis of the transcript.

There are several ways of presenting the results of case studies. The first is descriptive. The second is to combine analysis and description where, for example, direct quotes from interviews can be included and analysed. Another approach is to document the details of the case and then to discuss their implications.

8.3.3 Data Analysis

Additionally, documents, emails, correspondence among partners and to those outside the organisation, as well as formal and informal talks, can be analysed.

The selection of methods was based on the importance of having a qualitative-quantitative mix of methods as explained in the methodology.

8.3.4 Why Control 2K?

The choice of enterprise was considered very important because it would affect the research. It would also determine the level of access for carrying out fieldwork (geographical location of the enterprise, willingness to schedule for interview).

After careful consideration the decision was made to choose Control 2K due to the amount of their past collaboration activity, and for their core work in clusters and collaborations between SMEs. They call themselves a virtual enterprise and, at a first glance, have most of the characteristics which have been discussed earlier. They were also willing to assist in order to learn and to improve themselves as a virtual enterprise. The case study interview was undertaken by the researcher and consisted of an interview with two of the top managers.

8.3.5 Case Study Background

Control 2K consists of six permanent employees and four consultants and the annual turnover is about £400,000. They provide a number of business services in three main areas; training services, web and print design, and systems integrations. They have been providing business for the last decade. They are also an ISO 9001 registered company. Control 2K is a local company with a global reach. They are involved with a number of European research projects looking at developing internet and other software applications.

8.4 SME Cluster

An example of what Control 2K does is the SME Cluster which is a privately owned network that brings together the skills and product offerings of small local businesses in the South Wales region of the UK in order to be able to bid for much larger contracts in the public or private sectors than the individual SMEs could compete for alone.

Within an SME Cluster developing a structure, tools and website can assist a small number of members to form a VO with the result that more members can be a part of

it. This enables the members to inter-trade and share products at partner rates so that there are benefits of lowered costs for the members.

An SME cluster will provide services to companies, mainly small ones, to allow them to pull together and tender or quote for larger jobs. Most organisations nowadays tend to specialise in one area and often the requirements for larger quotes may require several disciplines. In addition, unlike the previous situation, an SME cluster facilitates enhanced communications between VO partners.

8.5 Collaboration Activities

In one of the past relationships that Control 2K had with their neighbours, where they required a supplier for a particular design, they were looking to set up a mechanism which could provide drawing and requirements which they saw as being a good business opportunity for them. So far as the other enterprise was concerned, it would have its design requirements met without having to employ its own people (outsourcing). That kind of relationship was very dependent where only the service had to be provided.

As described earlier Control 2K provides a diverse range of products and this could make it different from other enterprises which provide only one product or service. Every collaboration experience is different and partnerships with several enterprises have been tried where there has been successful collaboration with everything being delivered on time and on budget but, in the case of Control 2K, some of their business had actually been stolen by others involved in the collaboration. It is essential that Control 2K should make a profit and the same holds true for most of the other SMEs.

Control 2K found that one significant difficulty arose where they needed to fill jobs that demanded quite a high level of expertise since those people who already possessed the necessary skills were looking for high salaries thus putting a strain on profits. The best way forward seemed to be to recruit and train young graduates.

Control 2K was clear that there were some rules in existence for the networks in which it worked and it ensured that all those joining the network knew those rules. Having a contract and terms and conditions allows for a clear differentiation between those things that are allowed and those that are not.

Having common activities between the network members such as training, workshops, visits and meetings increases the flexibility of the members and could decrease the risks.

The level of trust can go in both directions while the collaboration is in operation and it becomes possible for it to increase when the partners become more comfortable with each other. However, it is also possible for it to decrease after the collaboration has been formed when what had seemed like good ideas when first put forward by the other partner had turn out to be different from what was first thought.

Control 2K's experience was that regular meetings increase trust whereas any conflict of interests decreases the level of trust between partners. Control 2K found that much of their attitude to trust arises from the experience of their own enterprise and observations where they have found that SMEs intend to trust people but that a failure in the collaboration gives a bad impression and so the next time the enterprise begins it will start it with less trust. Nevertheless, should an initial collaboration be successful, Control 2K believes that this may well influence the next collaboration so that there is more trust at the outset.

Most of collaboration decisions made by Control 2K are based on face to face meetings with partners.

8.6 Risks in Collaboration

Control 2K considers the biggest risk for SMEs to be financial, although other risks may arise with the brand (brand venture), for instance, if an organisation is part of a bad venture then its name and reputation are threatened by risk.

The risk sources impacting could be associated with time, money and quality but the quality may not necessarily be affected unless something is produced that is different or not expected.

It is difficult, the first time that a firm embarks on a collaboration, to assess the risks, since it is impossible to know what will be faced in the collaboration, but when more experience has been gained, it is easier to make judgments. One way to deal with this, Control 2K suggests based on their own experience that, the first project should be a

small one based on small steps and stages so that there is opportunity for trust and confidence to improve. Ground rules must be set and established.

In most of the collaborations that it undertakes, Control 2K shares the risks and rewards equally, and maintains that generally if you share the risks and rewards are also shared, unless it has been otherwise stated at the beginning of the collaboration.

8.7 The Role of the Broker

The broker should divide the responsibilities between partners; the broker takes charge in this area and decides how the project can be handled, intervening when partners do not want to accept their responsibilities. The broker operates in what can be seen as a command control environment.

Control 2K wanted to undertake the role of enabler rather than leaving it to a broker as would have been the situation in the past; for the future they wanted to be their own broker. The role of enablers can be described as partners deciding what is needed with the organisation providing the tools and services.

As an example, Control 2K are part of a team service (breeding manufacturing group) where they want to increase their buying power (based for example on the difference in price for having printed and buying one paper box and the price for one hundred).

The firm has had experience of about ten collaborations, where they had tried to get different people to do different things. Most of the VOs that the firm has had was with partners rather than clusters. The duration of these past VO varied from 1 year to 5 years with the average duration being 2 years.

It is clear that the original concept of Control 2K was to have a VO structure where it provided an umbrella organisation, consisting of:

1. Web service.
2. Industry service.
3. Training service.

When a number of people all offer different services they become a company.

In setting up a VO the broker should accept full responsibility and liability with the broker having a legal identity or else acting on behalf of a responsible body. The

division of work depends on the type of contract, and the terms and conditions have a degree of legal protection but at the same time it can never be guaranteed that they will stand up in court and legal issues are always the biggest problem for SMEs.

During the process of implementing the VO collaboration problems tend to arise when customers' specifications change from what was originally planned, and the work that the collaboration is undertaking turns out to be not the work that the customer requires. Sometimes it is not possible to do anything about this since the organisation is responsible to the customer. It may be possible to change the situation through negotiation but if this is not possible then the relationship must be terminated.

Meeting with partners is an essential element for a successful VO, using emails and video conferencing in parallel with meetings in order to ensure the success of the VO.

Those who are part of a VO should focus closely on what they are doing rather than attempting to focus more widely so that their focus is narrower but more concentrated. A VO can increase its scope (add value) by taking the opportunity in the future to work with other people who have become known to them. Control 2K has used a number of collaborative tools for the VO such as web portals and document sharing.

It is not possible to make trust happen, and Control 2K believes that trust happens spontaneously and follows naturally where integrity is ensured. In their opinion if an organisation always begins with integrity this will lead to trust.

Information sharing could be enhanced by using SMEs clusters where there are a number of good practitioners. On some occasions IT tools and marketing has let them down; they have been able to find good tools that do not have a business application (which is much the same as having a range of products for which users cannot be found). It has been important for them to understand and engage in business and use tools and they have thought that emails are the most obvious way of sharing information.

The top management commitment of partners should be self motivated and where they are pushed into certain undertakings, it may well cause problems.

The last phase of the VO life cycle is the dissolution. There is no legal format available to terminate the VO. It is more like a natural process, since where there is no

opportunity to continue the collaboration, something always happens. At the same time there is no true termination for a cluster and Control 2K believes that there should not be a termination for a cluster, because a project can finish but the cluster of VOs remains alive. At the termination there could be an agreement and understanding that there is no more business.

8.8 Understanding the relations

In the following sections the roles of communication, trust and commitment are discussed from Control 2K's point of view and their relationships to the others risk sources is taking place.

8.8.1 Communication

Control 2K do not have that much experience in collaborating with a distant partner, since the nature of its small business is local business unless there is a specific reason to collaborate with another partner in a distant geographic location or another country. They have found that having partners within the national area is not affected by delivery projections. There is a use for meetings which could be by emails or video conferencing but still face to face meetings result in a better commitment than video conferencing.

Control 2K believes that if it can be sure of having a common language for communications then collaborating with a different culture will not be a barrier to the VO collaboration, but if the situation should arise where there is no communication, then there would be no relationship. As ontology is the structure of relations, then relations between subsets using different ontologies will influence the collaboration agreement.

An inadequate collaboration agreement will lead to loss of communication and also to miscommunication which is potentially more dangerous than loss of communication. Miscommunication can be defined as a situation where each partner has his own ideas and each is doing different things but not necessarily the right things.

Where the partners are heterogeneous (with incompatibility between systems, syntax and semantics) it will not necessarily change the structure and design of the VO but may well prove to be a strength.

Having different partners who are doing different things may increase an organisation's capability but without a common language there will be a disconnection. Therefore heterogeneity may be a good thing within the context of working in a common framework.

Knowing the structure and design of the VO will make communication easier between partners in a VO because the partners know what the common framework is.

Control 2K recognises the need to increase the communication between partners until they have reached a point where there is a good quality of shared information and effective collaboration tools. Where these tools exist it should enable collaboration and could prompt people to ask and answer questions but at the same time they recognise that there is a need to be careful since too many portals and logs can constitute a bad use of collaboration tools which can unsettle the users.

8.8.2 Trust

There is no way to build trust without communication; the basis of trust is communication between partners. Furthermore an increase in communication between partners leads to better understanding of the requirements. When one partner works hard the other should work hard but when a partner sees that the others are not working his/her own work will become less effective.

It needs to be borne in mind that the loss of trust could happen at any time and there is no guarantee of not losing IPR; trust is essential in any collaboration but at the same time there is no guarantee that it will remain. In the formative phase of the VO collaboration enterprises should have a minimum level of trust to start their collaboration. If there is a great deal of trust between partners they may look for other opportunity together. Once the trust exists it is a partner's duty to send warnings of any risks could threaten the VO.

8.8.3 Commitment

The relationship between trust and top management commitment is a different relationship because an enterprise could be committed to do something while possibly not having trust in it at the same time, so having commitment gives no guarantee of trust but lack of commitment will lead to a lack of trust.

Bidding for more than one VO at the same time is an indication that an organisation is looking for new business but this does not mean there is a lack of commitment in all circumstances since it may be that an SME has no choice but to look for business. Most of the time there is a need to bid for several VOs to be able to gain one opportunity. Risk occurs in the circumstance where the amount of work an enterprise commits to do, is in excess of its capabilities.

Finally it is believed that it is difficult to select the right partner for the collaboration without knowing the risks sources for the collaboration so it is necessary firstly to know what the levels of risks are before deciding to join the collaboration.

8.9 Risk weighting

Each of the three tables below will give an example based on the past experiences Control 2K has had where, in each table, the risk sources will be covered one by one with their risk perception and with fuller explanations given where possible. Having these three tables (8-1, 8-2 and 8-3) will give us more understanding of the risk sources and how they can change during the collaboration.

The first partner

Table 8-1 First Partner Experience

Risk Source	Risk perception	Explanation
1. Lack of trust between partners	Low→ High	There was a great deal of trust to start with.
2. Wrong partner/s selection	Low→ High	What was considered to be the right partner at the beginning may not seem the right partner by the end.
3. Information sharing between partners	Low→ High	It is important to share a great deal of information at first but not at the end.
4. Loss of communication	Low→ Low	There was a great deal of communication which was not lost at any level.
5. Inadequate collaboration agreement	High→ High	The collaboration agreement was very weak at the beginning of the collaboration and by the end of the collaboration it was realised that it should have been strong.
6. Lack of top management commitment	Low→ High	There was top management commitment at the beginning but not at the end.
7. Heterogeneity of partners	Low→ High	There was a similarity of outlooks at the beginning but not at the end; everything looked very different.
8. Ontology differences	Low→ High	There was a common language at the beginning but not at the end.
9. Structure and design	N/A	Nonexistent.
10. Knowledge about risks	Low→ Medium	It was thought that there was trust, and therefore there was no worry about the risks. However there needs to be more information about the risks although overall the collaboration should be seen as positive.
11. Culture differences	N/A	Control 2K was too easy-going whereas the other organisation was aggressive.
12. Bidding for several VO at the same time	Medium→ Medium	The partner was engaged in other work and there was bidding for several VOs at the same time, decreasing the level of trust.
13. Geographic location	Low→ Low	Local collaboration.

The second partner

Table 8-2 Second Partner Experience

Risk Source	Risk perception	Explanation
1. Lack of trust between partners	Medium→ Medium	Trust was reasonable at the beginning and at the end; this partner was a valued customer and when Control 2K decided to enter into collaboration, what they offered and what Control 2K offered did not conflict.
2. Wrong partner/s selection	Low→ Low	This collaboration was a natural partnership because Control 2K knew what the other partner could offer and they knew what Control 2K could offer, and it was therefore an organic development.
3. Information sharing between partners	Low→ Low	Information sharing was constant (in the medium range most of the time) and the regular face to face meetings helped to make clear everything that it was necessary to know.
4. Loss of communication	Low→ Low	Communications were stable in the medium level most of the time.
5. Inadequate collaboration agreement	Low→ Medium	Most things were documented (what should be done by Control 2K and what the other organisation should do and of course how to share the profit). It was recognised as being a reasonable agreement at the beginning but it could have been better for ending the collaboration.
6. Lack of top management commitment	Low→ Medium	Control 2K started with a high level of top management commitment at the beginning which diminished because the other business was focused on other things.
7. Heterogeneity of partners	Medium→ Medium	Control 2K recognises that they are different (but that was not a factor in this collaboration) and they believe that this did not affect the collaboration.
8. Ontology differences	Low→ Low	There was a common language.
9. Structure and design	Low→ High	Nonexistent.
10. Knowledge about risks	Low→ Low	Control 2K knew the risks at the beginning; they were aware of the risks but not afraid of them because they knew that none of them was very serious.
11. Culture differences	Low→ Low	Both partners have the same culture, even their enterprises look the same, for example they are the same size.
12. Bidding for several VO at the same time	Medium→ Medium	The partner firm was bidding for several VOs and Control 2K believes that, as a result, they were not focusing on Control 2K nor on their own part in the collaboration.
13. Geographic location	Low→ Low	Geographic location did not make any difference in this collaboration.

The third partner

Table 8-3 Third Partner Experience

Risk Source	Risk perception	Explanation
1. Lack of trust between partners	High→ Low	At the beginning there was no trust but at the end there was a considerable amount of trust.
2. Wrong partner/s selection	Medium→ Low	We would choose another partner. At the beginning it seemed that it might be necessary to choose another partner but by the end the collaboration had proved satisfactory and no-one else was needed.
3. Information sharing between partners	Low-Low	The amount of information sharing was enough to begin with and very good to end with; it increased slightly during this collaboration.
4. Loss of communication	Low-Low	Communications were consistent and reasonable from the beginning until the end.
5. Inadequate collaboration agreement	Medium→ Medium	Any partner could have been broker but Control 2K was the broker for this collaboration and the agreement was adequate.
6. Lack of top management commitment	High→ Medium	The commitment of the other partner was low but Control 2K believes that this did not affect the level of trust; however Control 2K's commitment was high.
7. Heterogeneity of partners	Medium→ Low	The similarities increased during the collaboration.
8. Ontology differences	Low→ Low	The partners shared a stable common language during the collaboration.
9. Structure and design	High→ Low	Nonexistent.
10. Knowledge about risks	Low→ Low	Although the risks were known, this did not affect anything except the profitability.
11. Culture differences	Medium→ Medium	Although there was a substantial difference in culture, it did not affect the collaboration that much.
12. Bidding for several VO at the same time	Medium→ Medium	This had an effect on collaboration because both partners engaged in this, but people understood why it was done.
13. Geographic location	Low→ Low	The partner was in close proximity to Control 2K (local collaboration); being so close helped the collaboration because each partner could have immediate access to the other and being so close was felt to be a substantial advantage.

8.10 Findings and Discussion

This has been used as a case example in an attempt to link theory and practice. In order to do this initially some of the major issues faced by virtual organisation have been discussed.

The background to this choice of case study was then briefly explained along with the research approach. In conclusion it has been argued that the effort to date and the progress made have been significant but that there are areas where extra effort could add value.

Enterprises need to cope with growing competitiveness in terms of costs, time and quality pressures and with growing uncertainty in the internal and external environment. Collaboration is a means to share resources, combine competencies and reduce risks, and being perceived as a valid partner has become an asset (Kanter, 1994). There were some problems finding the balance between keeping information confidential and sharing necessary information.

Organisational interface problems are more complicated than technical interface problems, because the people involved develop personal objectives, the organisations that want to co-operate have organisational goals, and the representatives of the entities involved in the interface tend to digress in their perception of the decision environment. Therefore, interfaces need to be managed and mechanisms developed to bridge these interfaces where they cannot be avoided.

8.11 Conclusion

The collaboration between SMEs has become vital in enhancing order fulfillment performance and developing competitiveness and this collaboration between SMEs has exposed business to new risk sources. In order to gain deeper understanding of these dynamic phenomena, case studies are frequently used as a research approach in supply chain and virtual organisation research, both of which are relatively new research areas.

In particular, the case study method used was the “single case design” as Yin (1994) has called it, with a single unit of analysis and only one case. Research by case study

was preferred, since it enables a more descriptive and exploratory approach allowing for richer insights into the research object (Yin, 1994; Miles and Huberman, 1994).

The case study enterprise was screened initially through a face-to-face interview, and e-mails. Information gathering techniques implemented during execution of the case study included obtaining historical data, documentation and conducting structured interviews.

This chapter indicates that enterprises are more exposed to risks and are increasingly faced with the challenges of dealing with predictable and uncertain events. It is of paramount importance that such enterprises, which are exposed to high levels of risks, identify and manage risks in this dynamic VO relation and develop risk reducing strategies to avoid adverse effects. Competitive advantage has become more difficult to achieve in this dynamic environment.

Risk management is not a new idea and enterprises have long identified, analysed, and mitigated risk. Also the risk is not static and it must be recognised that as VO evolves so do the risks and thus the need for their subsequent management.

Chapter 9 Discussion and Findings

9.1 Introduction

The purpose of this thesis is to work towards a comprehensive study of the risk in SMEs collaboration and in order to do that the author set out to fulfill the research objectives (Chapter 1).

The preceding chapters of the thesis have presented the research from the literature review through to the results gained from surveys and the case study. The aim of this chapter is to draw all of the key elements together in a discussion to allow greater understanding of the research results. The analysis of this data has produced significant results which need to be discussed and interpreted accurately to achieve the research aims. This discussion is linked to the aims and objectives of the research and is also linked to the related literature.

A hybrid methodology utilising the symbiotic relationship between quantitative and qualitative studies was utilised. The research focused on collecting and analysing both quantitative and qualitative data in the study. For the sequential mixed method strategy of this research, analysis occurred within both the quantitative and the qualitative stages of research.

The secondary research identified all of the risk sources in the relevant literature and some of the relationships between them, whilst the primary research addressed all of the direct and indirect relationships using the Interpretive Structural Modeling (ISM). Also the primary data sources (questionnaires and the case study) shed light on the relative importance of these sources which could not be found in the secondary research.

9.2 Discussions of the Research Findings

Thirteen risks sources have been identified and several relationships between sources have been identified with much discussion on some of these relationships, less on others. This gave an indicator of the relative importance of these sources and their relations. The next section examines four of these risks (loss of communication, lack

of trust, top management commitment and information sharing). These four have been chosen rather than all of the sources since this could make other relations clearer.

9.2.1 Loss of Communication

Much research recognises that the crucial element in VO collaboration is communication, and there has been significant discussion of the need that exists for communication to be effective.

According to Boutellier et al. (1998) and Roberts (2000) trust and confidence within a relationship improves where there is face to face contact and a social relationship between the partners, as well as a readiness to exchange information.

As a result those difficulties with communication which appear where culture and language is different can be removed. Where a VO is scattered geographically, face to face contact cannot take place as often as when the partners are situated in some proximity. However this problem can be addressed by the use of communication using ICT tools such as video conferencing and email.

The experience gained from Control 2K case study has supplied the evidence that where enterprises make it easier for there to be frequent interaction and communication using video conferencing and emails, this leads to improved performance and enhanced cooperation.

It is therefore vital that trust between the partners who are working together should be increased so that uncertainty is reduced as well as the complexity associated with certain tasks. Communication has usually taken place through the use of emails or conference calls, and knowledge that was otherwise unspoken could be conveyed during meetings through presentations and discussion with explicit knowledge being disseminated through the use of shared documents. It is therefore seen that the extent of trust between both individuals and organisations has an impact on uncertainty and therefore progress within a VO.

It has been stated by Grabowski and Roberts (1998) that where there is communication within a VO relating to the responsibilities of partners and their relationships, links between the partners as well as differences can be made clear. The primary research undertaken for this thesis also supports the fact that arranging

regular meetings and setting up the communication channels can bring about an improvement in communications. However, although ICT tools bring with them many advantages, they also bring technological challenges such as the incompatibility or else lack of availability of hardware/software, as well as the complex nature of infrastructures and equipment (Haywood, 1998).

It is common for cultural and language difficulties to arise within a VO and this is often seen as constituting a barrier (Kayworth and Leidner, 2000; Sarker and Sahay, 2002; Baugher and Weisbord, 2000; Larkey, 1996), with these proving to be an obstruction in the way of successful communication. In these cases worthwhile communication may not have taken place. It is also the case that because of cultural differences the way that language is used and the precise meanings of certain words vary across different countries. Such misunderstandings cause frustrations for both partners and the collaboration may lose sight of its objectives. On the other hand it is recognised that more effective communication is able to help with cultural understanding (Robey et al., 2000; Van Ryssen and Hayes Godar, 2000). Where efforts are made to be aware of the differences, the negative effects stemming from language and cultural difficulties can be mitigated (Robey et al., 2000; Sarker and Sahay, 2002) through the use of frequent communication and through referring issues for more discussion where that proves necessary.

Where communication has been poor it has been significantly detrimental to trust and therefore damaging to relationships, with partners not feeling able to place reliance on work, demonstrating that any unreliable partner impedes progress.

It is vital to share information if there is to be effective communication and Hollingshead (1998) argues that it is clear that for communication to thrive there must be mutual knowledge and each partner must be able to understand the information held by others, showing that where communication is effective the transfer of knowledge is positively affected.

Those taking part in our case study have had limited experience of working with a distant partner and where there are partners within the national area this does not impact on the delivery of the project. While it is useful to communicate via emails or video conferencing, meetings that are face to face lead to increased commitment and this is in line with the findings examined in the literature. The case study also made it

clear that communication is crucial to a collaboration and without it there is, in effect, no relationship.

Ontology is concerned with the structure of relationships and with the relationships existing between subsets and therefore the use of different ontologies will have an impact on the collaboration agreement. Where the collaboration agreement itself is poor communication will suffer, with inaccurate communication having potentially more adverse effects than no communication at all.

Communication between partners is made easier where the structure and design of the VO is clear since the partners will be aware of the common framework. Where communication is increased so will be the sharing of information with collaborative tools leading to question and answer exchanges.

What this discussion makes clear is that good communication in a VO is able to make clear what the goals are, enhance relationships and clarify the responsibilities of each partner as well as provide those belonging to the VO with the opportunity to discuss possible improvements. ICT tools enable communication to take place across organisations, transcending differences in time and place. However, where there are cultural differences, there can be an adverse effect on effective communication, although this can be overcome by communicating frequently.

Information sharing is made possible by effective communication and it is also possible to establish good trust. Of all the risk sources previously mentioned, poor communication can have the most negative effect where, as discussed in the ISM, it is to critical only link between the independent and dependent risk sources. The relationship that exists between loss of communication and other sources has been covered in the ISM model (Chapter 6). The model makes clear that the linkage source provides a link between geographic locations, between cultures and ontology differences, between inadequate collaboration agreement and structure and design, and in circumstances where differences between partners have led to problems with design and structure. It has also shown that where there is loss of communication, it may result in adverse impacts on other apparently dependent risk sources, such as lack of top management commitment, of trust and information sharing, as well as bidding simultaneously for several VOs, and having lack of knowledge about the risks involved and engaging in a poor selection of partners. The relationships between

sources are more complex here than in the lower level of the model and there will therefore be further explanation in the next three sections, where trust will be discussed as well as lack of top management commitment and information sharing.

9.2.2 Lack of Trust between Partners

It can be argued that the still developing areas of risk and relationship management have trust as their basis (Morgan and Hunt, 1994). Where there is a good trust between partners, commitment is increased (Mistry, 2005), and Lengnick-Hall (1998) puts the case that where trust has been built up through effective communication this can lead to the creation of resources that confer a competitive advantage. (Lewicki et al., 1998, Zaheer et al., 1998) both state that trust is the basis of social, political and economic exchange because of the onus it places on one party to make some kind of approach to the other with the implicit assumption that the other party will make a positive response.

According to Fukuyama (1995) there is an impact on trust from both nationality and culture with the degree of trust existing within the economic environment varying from one culture to another. Boisot (1998) goes on to state that, “those cultures that have a tradition of tolerance and pluralism are better placed to profit from the internationalisation of trust". However, for trust to be established where the national or cultural background is different, a greater effort must be made than is needed to establish trust between those who share both a social and environmental background which may also be more conventional in its attitudes than some others (Roberts, 2000).

It is also the case that where trust is developed between individuals, the ability to contribute to mutually held understanding will increase as will the awareness of social and cultural contexts that are shared. However, where there are cultural differences they have the potential to impact negatively on communication which in turn impedes the development of trust.

Discussing the relationship between trust and a collaboration agreement Panteli and Sockalingam (2005) considered trust and conflict against a background of a virtual inter-organisational agreement as an issue likely to be intrinsic to any organisational agreement that is made. Where trust exists within an enterprise there will be a

perception of less risk attached to sharing sensitive information and there will be a reduced need for complex contracts to protect interests. Instead there will be a reliance on each other to make appropriate decisions since each will consider that their particular perspective will be respected.

When considering the many aspects of various cultures the most important is collaboration and trust, trust being an attribute of a knowledge friendly culture that cultivates the relationship between individuals and groups so that knowledge sharing becomes increasingly positive and open. A VO may contain several cultures and this may lead to incompatibility problems with regard to process, poor communication and its impact on trust and the sharing of information.

Our primary research indicated that trust cannot be built without communication since trust is founded on communication between partners and where communication between the partners increases, so also does the understanding of requirements. When one partner is working hard, it is necessary that the other partner should work hard too, since if there is a perception by one partner that the other is not working as he should, all the work undertaken is rendered less effective.

There are eight sources that have an impact on trust: geographic location, culture, ontology, heterogeneity, collaboration agreement, structure and design, information sharing and top management commitment.

Trust itself can increase the commitment from top management as well as increasing information sharing and knowledge of risks but, when trust is lost, this can result in bidding for more than one VO at the same time and to the selection of unsatisfactory partners.

It should be borne in mind that trust can be lost at any time and there is no guarantee that IPR will not be lost: while there must be trust in a collaboration, there is equally no guarantee that it will remain. When a VO collaboration is being put into place there should, in fact, be a minimum level of trust. Where there is little trust between partners they may seek other opportunities but once trust exists a partner is able to warn in the event of there being any risks that could pose a threat to the VO.

9.2.3 Lack of top Management Commitment

From the point of view found in our case study, the relationship existing between trust and top management commitment is different because while there may be a commitment from an enterprise to undertake a certain course, simultaneously there may not be trust in this course, which indicates that commitment does not come with trust guaranteed but where there is no commitment, then a lack of trust will follow.

Where more than one VO is bid for at the same time, it suggests that new business is sought but it does not necessarily indicate a lack of commitment since there are occasions when it is necessary for SMEs to look for new business. It is the case that, generally, more than one VO has to be bid for in order to gain a single opportunity. Risk occurs when any enterprise undertakes to do more work than its capabilities can sustain.

From the results of the survey (ISM model) it is possible to see that lack of commitment by top management is an important risk source with many relationships dependent on the seven sources of geographic location, culture, ontology, heterogeneity, structure and design, inadequate collaboration agreement and communication. Lack of top management commitment has two vital areas of relationship, these being lack of trust and information sharing. Finally lack of top management commitment may lead to bidding for more than one VO at the same time, as well as having an increased knowledge about risk source and of wrong partner/s selection.

9.2.4 Lack of Information Sharing

It is crucial for collaborations that information should be shared, since the lack of information visibility within a VO will increase risks, e.g. availability of catalogues with updated profiles of organisations not being available, while an increase in information sharing can lead to a loss of IPR.

If sharing and collaboration is not crucial to its core content, then members of a VO will not accept the importance of sharing knowledge because they may believe that their certain knowledge which others do not possess confers on them an advantage within the enterprise, and consequently they will not be prepared to share their

knowledge with others because they believe that this stance will protect their own interests (You et al., 2006).

Where the free exchange of information begins as early as the stage where the product or service is being developed and then continues right through the operation until it reaches the end of the life phase of the product cycle, it has been seen to be very effective in relation to the reduction of risks that are associated with inventories, outliving usefulness, and failure of the supplier (Lee et al., 1997; Lee, 2002). The inception of internet use and e-commerce has given everyone taking part in an supply chain the opportunity to transfer information in real time with a minimum cost for the transaction and across a global reach (Zeng and Pathak, 2003) so that there has been a substantial fall in the costs of coordination and distribution (Koh and Nam, 2005).

The extent to which information is actually shared is dependent on choosing a suitable partner with whom to share information, and the type and quality of the information that is to be shared. It has been found by a number of studies that the sharing of information has a significant effect on the partnership performance. It is also the case that the sharing of information leads to enterprises making better decisions in relation to their operations so that resources are better used and costs are reduced (Lee et al., 1997; Yu et al., 2001).

However, it is possible that some enterprises may not wish to share detailed information with their partners, feeling that the sharing of such data will only enhance the capability of their competitors. Therefore, such enterprises may be prepared to only release aggregated data on a category level of products without revealing any of the details that may be needed.

There are a number of relationships within the areas of lack of information sharing as the ISM shows which are dependent on geographic location, culture differences, ontology differences, heterogeneity of partners, lack of structure and design, inadequate collaboration agreement and loss of communication. Lack of information sharing is related to both lack of trust and lack of top management commitment and, finally, the sharing of information leads to an increased knowledge of threats that could damage a VO whereas poor information sharing can lead to the selection of the wrong partner/s.

Table (9-1) below summarises the relationships found in both primary and secondary research as discussed above

Table 9-1 Risk Sources Relationships Summary

Loss of Communication	
Secondary Research	• Trust and confidence within a relationship improves where there is face to face contact and a social relationship between the partners, as well as a readiness to exchange information. • Communication shows the responsibilities of partners and their relationships, links between the partners as well as differences can be made clear with more communication. • ICT tools bring with them many advantages; they also bring some incompatibility between technologies. • Cultural and language difficulties occur within a VO and this is often seen as constituting a barrier for successful communication. • Meanings of certain words vary across different cultures or countries; such misunderstandings cause frustrations for both partners and the collaboration may lose sight of its objectives where more effective communication is able to help with these misunderstandings.
Primary Research	• The experience gained from Control 2K case study has supplied the evidence that where enterprises make it easier for there to be frequent interaction and communication using video conferencing and emails, this leads to enhanced cooperation. • Poor communication has been significantly detrimental to trust and therefore damaging to relationships, with partners not feeling able to place reliance on work, demonstrating that any unreliable partner impedes progress. • Control 2k also made it clear that communication is crucial to collaboration and without it there is, in effect, no relationship. • Ontology is concerned with the structure of relationships and with the relationships existing between subsets and therefore the use of different ontologies will have an impact on the collaboration agreement. Where the collaboration agreement itself is poor communication will suffer, with inaccurate communication having potentially more adverse effects than no communication at all. • Communication between partners is made easier where the structure and design of the VO is clear since the partners will be aware of the common framework. • Information sharing is made possible by effective communication and it is also possible to establish good trust. • Communication is so critical where it is the only link between the independent and dependent risk sources, between geographic locations, between cultures and ontology differences, between inadequate collaboration agreement and structure and design, and in circumstances where differences between partners have led to problems with design and structure. • Loss of communication may result in adverse impacts on other apparently dependent risk sources, such as lack of top management commitment, of trust and information sharing, as well as bidding simultaneously for several VOs, and having lack of knowledge about the risks involved and engaging in a poor selection of partners.

Lack of trust between partners	
Secondary Research	• Trust between partners increases the commitment. • Effective communication built up trust which this can lead to the creation of resources that confer a competitive advantage. • The degree of trust existing within the economic environment varying from one culture to another. • In different national or cultural background a greater effort must be made than is needed to establish trust between those who share both a social and environmental background which may also be more conventional in its attitudes than some others. • If trust exists there will be a perception of less risk attached to sharing sensitive information and there will be a reduced need for complex contracts to protect interests.
Primary Research	• A VO may contain several cultures and this may lead to incompatibility problems with regard to process, poor communication and its impact on the trust and sharing of information. • Trust cannot be built without communication since trust is founded on communication. • There are eight sources that have an impact on trust: geographic location, culture, ontology, heterogeneity, collaboration agreement, structure and design, information sharing and top management commitment. • Trust itself can increase the commitment from top management as well as increasing information sharing and knowledge of risks but, when trust is lost, this can result in bidding for more than one VO at the same time and to the selection of unsatisfactory partners.
Lack of top management commitment	
Secondary Research	• Limited top management commitment to partnership increase the risk exists and failure chance to meet objectives in particular in relation to the creation and sharing of knowledge. • Mutual agreement can provide limits to commitment and trust.
Primary Research	• Commitment does not come with trust guaranteed but where there is no commitment a lack of trust will follow. • New business sought more than VO bid at the same time which does not necessarily indicate a lack of commitment since there are occasions when it is necessary for SMEs to look for new business. It is the case that, generally, more than one VO has to be bid for in order to gain a single opportunity. Risk occurs when any enterprise undertakes to do more work than its capabilities can sustain. • It is possible to see that lack of commitment by top management is an important risk source with many relationships dependent on the seven sources of geographic location, culture differences, ontology differences, heterogeneity of partners, lack of structure and design, inadequate collaboration agreement and loss of communication.
Information sharing	
Secondary Research	• If sharing and collaboration is not crucial to its core content, then members of a VO will not accept the importance of sharing knowledge because they may believe that their certain knowledge which others do not possess confers on them an advantage. • Sharing of information has a significant effect on the partnership performance. • Sharing of information leads to enterprises making better decisions in

	relation to their operations so that resources are better used and costs are reduced.
Primary Research	• Lack of information sharing as the ISM shows are dependent on geographic location, culture differences, ontology differences, heterogeneity of partners, lack of structure and design, inadequate collaboration agreement and loss of communication. • Lack of information sharing having bidirectional relation on both lack of trust and lack of top management commitment. • The lack of information sharing leads to an increased knowledge of threats source that could damage a VO whereas poor information sharing can lead to the selection of the wrong partner/s.

9.2.5 Interpretive Structural Modeling

The objective of the ISM model in this research is to develop a hierarchy of risk sources that will help mitigate risks in a VO. The model developed provides the opportunity to understand the risk source relationships at a network level in the VO. It is clear that awareness about risks sources is very important as it can lead to the undertaking of efforts to minimise these risks.

A more complete understanding of these risks sources and their relationships, through logical structure, will help partners to make better decisions on whether to join the VO or not and even to assess the risk in the collaboration process. Risk sources in the VO have become more integrated and dependent on partners' relationships.

Since ISM can only act as a tool for imposing order and directions on the complexity of relationships among the sources as previously explained in chapter (6) it does not give any weight associated with the variables, so ANP has also been used.

9.2.6 Analytical Network Process

A primary study was used to determine the relative importance of the risk sources after subjectively evaluating pairs of these risk sources. The final weight for each risk source, representing its relative importance, is provided in chapter 7.

The ANP proved to be a very powerful and appropriate tool for assessing the decision problem faced by the enterprise resulting in a high confidence level for implementing the suggested solution. An additional strength of ANP lies in its ability to incorporate qualitative criteria, as well as uncertainty which is present in decision-making. The decision could have been made by just looking at the risk sources and then coming up

with an apparent best solution, without employing ANP. However, with so many risk sources involved and because alternatives could be involved, this approach would have been rather haphazard. While it can be easy to make a decision among alternatives across two or three risk sources, 13 criteria are much more challenging to handle. Therefore the application of ANP is recommended not only when making collaboration decisions, but for any Multi-Criteria Decision-Making (MCDM) problem involving uncertainty. The outcome of ANP does not only provide more confidence in the final decision, it is also an excellent way for an enterprise to justify its decision.

As such, the catalogue of risk sources was identified via an in-depth literature review and an expert questionnaire, and represents a comprehensive set of issues describing the situation of enterprises in a VO. While these factors and their weights could be different for other enterprises, the process employed to derive them is an approach to be recommended. Similarly, the set of risk sources identified can serve as a starting point for other enterprises in the exploration of their risks. This provides for a much stronger foundation to make a correct decision, instead of merely thinking through all the possible risks and alternatives. The approach ensures that no relevant risk factor is forgotten, and that all issues are considered. The research can thus serve as a template and inspiration for SMEs joining a VO.

However, alternatives have to be re-evaluated on a continuous basis, and risk sources have to be reassessed to account for potential changes that are occurring in the environment; it is an evolving process. The ANP serves as an outstanding tool in this regard, since once the comparison matrices have been set up, they can be revisited and evaluations can be adjusted easily based on changes that may have occurred. For instance, some risk sources may diminish in significance, while the importance of others may increase. Moreover, additional risk sources not considered in the present decision may emerge, and others may disappear completely. Having made a successful decision, the enterprises continuously keep an open mind to identify even better alternatives that may emerge. Using the ANP gave different rankings than the ones in the first questionnaire (chapter 5) where the ANP gave the respondent the opportunity to compare between each of two risk sources at one time. This gave us

better results than the first questionnaire and at the same time gave a weight for each source compared with other sources.

9.3 Findings and Discussion

Control 2K was used as a case example in an attempt to link theory and practice. The background to this choice of case study is then briefly explained along with details of the adopted research approach. In conclusion, the effort to date and the progress made have been significant but that there are areas where extra effort could add value.

Enterprises have to cope with increasing competitiveness in terms of costs, time and quality and with growing risk sources in the network environment. Collaboration is a way to share resources and unite competencies, but with this new form of work between enterprises emerges new risk sources, such as finding the balance between keeping the information confidential and giving necessary information.

Organisational problems are more complicated than technical problems, because the people involved develop personal objectives and the organisations that want to collaborate have organisational goals. Therefore, conflicts need to be managed and tools developed to bridge these conflicts where they cannot be avoided.

One of the important things found in the case study investigation was that the risk source weights could change during the collaboration and could have different levels for the same partners so the enterprise needed to keep watching the risk sources variation during the operation of the collaboration.

9.4 Future Work

In the future research, a graph theoretic approach can be applied to develop quantitative measures of these risk sources. The graph theoretic approach complements the ISM methodology, although the ISM model provides a very useful understanding of the relationships among sources, it does not provide quantification of the impact of each source on risk mitigation.

The graph theory and matrix methods consist of the digraph representation, the matrix representation and the permanent matrix representation. The digraph is the visual representation of the sources and their interdependencies. The matrix converts the

digraph into mathematical form and the permanent function is a mathematical representation that helps to determine the numerical index.

To present an approach to quantify these risk sources would help decision-makers to estimate the impacts of various risk sources and consequently develop suitable strategies to counter them. Therefore, it would enable them to have robust comprehensive risk sources mitigation policy in place.

Furthermore, fuzzy ISM, which can be an improvement over binary ISM, may also be carried out. While only the existence of relations is considered between elements in the ISM, the strength of relations is additionally considered in FISM. The strength of relations can be quantified using a 0-1 scale.

Additional future research could include broadening the inputs and validation with more practitioners and evaluating an actual set of risk sources in a real case study with an experimental approach to determine if the model's relationships are influenced as hypothesised on expert opinions.

Structural Equation Modeling (SEM) has the capability of testing the validity of such hypothetical models. Therefore, it may be applied in the future research to test the validity of this model. SEM models can be tested using LISREL or AMOS software. SEM models also provide the path coefficients for the different relationships among the sources. This would complement the MICMAC analysis to further strengthen the understanding of the more important relationships requiring maximum attention.

Finally an integrated solution based on ANP and ISM models can be set as an appropriate base for the development of the balanced scorecard (Thakkar et al. , 2007) where the relationships obtained through the development of ISM are utilised as inputs for the construction of ANP model (Thakkar et al., 2005). Specifically, a combination of ISM and ANP is attractive in a way that ISM can satisfy the input demand of ANP and output of ANP results in a more usable outcome, which is sometimes not possible with the use of any one technique.

9.5 Conclusion

Collaboration between SMEs has become vital in enhancing order fulfillment performance and developing competitiveness, but this collaboration between SMEs has exposed business to new risk sources.

Case studies are frequently used as a research approach in supply chain management and VO research, both of which are relatively new research areas. The case study enterprise was screened initially through a face-to-face interview and e-mails. Information gathering techniques implemented during execution of the case study included obtaining historical data, documentation, and conducting structured interviews.

This chapter indicates that enterprises are more exposed to risks and are increasingly faced with the challenges of dealing with predictable and uncertain events. It is of paramount importance that such enterprises, which are exposed to high levels of risks, identify and manage risks in this dynamic VO relation and develop risk reducing strategies to avoid adverse effects.

Competitive advantage has become more difficult to achieve in this dynamic environment. Even risk management is not a new idea and enterprises have long identified, analysed, and mitigated risk. Also the risk is not static and it must be recognised that as a VO evolves so do the risks and thus the need for their subsequent management.

Knowing more about the risk sources gives the enterprise more opportunity to decrease the likelihood of adverse events occurring and could make collaboration between the SMEs easier and safer.

To conclude this thesis, this chapter summarises the achievements of the research which match the aim and objectives specified in Chapter 1.

Specifically, this research includes the following:

This chapter started with an overview of the research background, then the major findings and contributions in terms of the research objective of the thesis are highlighted, leading to a discussion of the key issues and heuristics derived from surveys and the case study with a view of the relevant literature.

Following this, a reflection on the results from the primary research is undertaken along with a discussion of the relevant literature. Potential emerging issues are also identified and discussed.

The thesis makes a significant contribution to providing the platform for future research in this increasingly important field.

Chapter 10 Conclusion

10.1 Introduction

This chapter summarises and draws conclusions from the study with respect to the research objectives identified in Chapter 1. The research comprises a study of related literature (Chapters 2, 3), detailed discussion of the research hypotheses and research methodology (Chapter 4), the risk sources identification (Chapter 5), empirical analysis of the data ISM and ANP from the surveys (Chapters 6, 7) and discussion and finalisation of the suggested case study analysis (Chapter 8). This chapter highlights the significant research contributions this study makes to the field of risk management in VOs. The future research scope emerging from the research study is also discussed.

10.2 Research Methodology

In order to achieve the objectives of the study, thorough research in the Virtual Organisation and risk management subjects was undertaken. This involved a thorough literature study. The risk management discipline, in practice was a challenge because of the relatively immature nature of risk management science with regard to the VO. In addition to the above, three surveys were sent to experts in the field and finally a case study was conducted with an enterprise having a great deal of experience in VO collaborations.

A hybrid methodology utilising the symbiotic relationship between quantitative and qualitative studies was applied. Saunders et al. (2009) have suggested that it is often beneficial to use a mixed methods approach by combining quantitative and qualitative methods and to use primary and secondary data in the same study, as using different methods for different purposes helps the study and enables triangulation to take place at the results formulation stage.

The research focused on collecting and analysing both quantitative and qualitative data in the study. For the sequential mixed method strategy of this research, analysis occurred within both the quantitative and the qualitative stages of research.

10.3 Significant Research Contributions

The author believes that this research has followed the recommended approach by Bellenger and Greenberg (1978) as explained in section 4.5 and has made the following significant contributions:

10.3.1 Literature Survey

As per the literature survey findings, until now such a study and survey has not been conducted with reference to the risks sources in VO. Thus, this study provides a direction pattern for research into risk sources in SMEs collaborations.

10.3.1.1 VO Collaboration

Collaboration is the term used to describe organisations that are working together but where the association exceeds a normal commercial relationship. It goes beyond the more guarded exchanges associated with market operations to an association which is more relational, since the simple exchange of the ownership of goods that is normally associated with buyer and supplier is not sufficiently broad to accommodate the concept of collaboration. Collaboration comes into being at the point where business openings are realised to exist but where working as individuals will not be enough to achieve the desired goal.

The term collaboration is two or more enterprises becoming involved to actively work together across the existing boundaries of their organisations in order to meet and satisfy the needs of customers. While there are a number of advantages in this, there are also disadvantages so that it is true today that while benefits can flow from collaboration so also can risks and this has been in the focus of our research.

10.3.1.2 Risk Sources in Virtual Organisations

Risk sources in VOs have been identified by many authors who have researched and written on this issue. In this research, after analysing literature critically, thirteen risk sources were found in the network related risks of the VO:

1. Lack of trust between partners.
2. Lack of top management commitment.
3. Lack of information sharing.

4. Inadequate collaboration agreements.
5. Ontology differences.
6. Heterogeneity between partners.
7. Structure and design.
8. Loss of communication between partners.
9. Culture differences.
10. Geographic distribution.
11. Lack of knowledge about risks.
12. Bidding for several virtual organisations at the same time.
13. Wrong partner/s selection.

The potential results of these risks are failure to meet delivery time, cost, and lack of quality targets or total failure for the collaboration.

One result which could stem from undertaking this research and identifying the sources of risks, is that SMEs could be given the opportunity to improve their work through adopting some of the following actions that could lead to improved VO bringing the partners greater benefits:

- There could be increased communication between partners so that all are better informed with a better exchange of documents relating to decisions, requests, and other matters that need to be common knowledge. There should be an integrated and comprehensive format in use for information, documents and messages so that all the enterprises involved in any particular collaboration have access to the same information. However, care must be taken when this information is disseminated so that the risk of any unauthorised access is kept to a minimum.
- It is important that documents should have a unified structure as this enables them to be processed in such a way that it makes it much less likely that misunderstandings will arise. For example when a definition is sought in a technical dictionary, there is often more than one available for any particular word or expression in a specific industry, which may well result in different understandings being reached by different people.
- It is important that the core competencies of enterprises are defined so that there can be an appropriate division of tasks during a collaboration.

- The structure of enterprises and the explanations of them should remain simple so that everyone can easily find what they need.
- If there are any conditions attached to a particular enterprise these should be explained before the cooperation begins.
- The storage of business information and membership of the enterprise may be helpful when a VO is formed and could provide the most efficient way for saving, retrieving and searching the information relating to the enterprise.
- Where there is a good contract the commitment of the parties is likely to be increased.
- Knowing the risk sources make it easy for the enterprise to make a less risky decision and minimise the threats of the VO collaboration.

10.3.1.3 Interpretive Structural Modeling

Interpretive Structural Modeling (ISM) analysis provides a roadmap for the SMEs to see the relations between the risks sources.

The risk sources identified in this research have significant overlaps and relationships that are sometimes difficult to see. A more complete understanding of these risks sources and their relationships, through logical structure, will help enterprises to take a more informed decision as to whether to join the VO as the result of the presentation in this research of a description of the ISM process.
Simulation and systems dynamics modeling may also be used to help identify how risk sources in a VO will influence it and its performance results

10.3.1.4 Analytical Network Process

Analytic Network Process (ANP) is a comprehensive decision-making technique. ANP captures interdependency among the decision attributes and allows systematic analysis. It is the decision making tool which helps a decision to be arrived at rather than providing an understanding about the relationships among the variables under consideration. Using the ANP technique for evaluating weights has helped with the task of prioritising and defining both the part played by sources of risk and their relative importance and this helps in the making of two decisions: deciding which sources of risk are the most important and setting up the priorities for risk management.

10.3.1.5 Case Study

The application of the developed work has been demonstrated in a real VO case. The case study enterprise was screened initially through a face-to-face interview, and e-mails. Information gathering techniques implemented during execution of the case study included obtaining historical data, documentation and conducting structured interviews.

This case study indicates that enterprises are more exposed to risks and are increasingly faced with the challenges of dealing with predictable and uncertain events. It is of paramount importance that such enterprises, which are exposed to high levels of risks, identify and manage risks in this dynamic VO relationship and develop risk reducing strategies to avoid adverse effects.

10.4 Limitation and Weaknesses

Below is a summary of the limitations and weaknesses of the research:

- Low response rate for the second and the third questionnaire.
- The narrow, idiosyncratic outcomes of case study may not yield much in terms of generalisable outcomes or theory.
- Those completing ISM and ANP questionnaires may find it a tiring task since it demands significant concentration and it is time consuming.
- ISM and ANP relies on the fact that knowledge and judgement as well as the principles of those who make the decisions have an equal value.

10.5 Future Research

We can plot some directions for future research based on this work.

1. This research is based on 13 risk sources so an extension of this work could add more risk sources if any appear in the future.
2. While the research was conducted in the European Union countries, the research outcome is envisaged to be widely applicable anywhere.
3. An improvement to the way of using ANP could take place in the future since this method is based upon getting the inputs for ANP matrices. This can be improved by plugging in a module to compute the probability based on collected historical data.

4. While using graph theory and matrix method the interactions among the sources can be analysed and they can even be transformed into mathematical equations.
5. Finally a link between the ISM outcomes to ANP models and using the ANP results for balance score card can provide a better understanding of the interrelationship amongst the evaluation of the risk sources.

10.6 Summary

This research has identified key areas of risk that SMEs are likely to face when working collaboratively in VO. It also enables SMEs to understand the relative importance of these risks. A further contribution is made by use of tools (ISM and ANP) to enable SMEs to understand the inter-relationships of risk sources. If additional or different risks are identified by an SME, a similar analysis approach could be used to understand their importance and their relationships with other know risks.

Multiple analysis techniques provide triangulation of analysis results, leading to validation of results. This chapter summarises the major findings leading to a discussion of the significant research contributions, the implication of research for industry practitioners as well as for academics. Areas for further research are suggested to close the gaps and to continue enriching the research.

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Appendix

Appendix 1

Cover letter

I am a PhD research student at Coventry University conducting a study to investigate the risks in forming and operating Virtual Organisation collaboration. The research title is:

Collaboration Risk Evaluation and Management for SMEs.

I am using the Delphi method of expert opinion elicitation, with a three of questionnaires to conduct this study. The first round addresses assessment of the risk sources in the virtual organisation collaboration.

My work is closely related to the SYNERGY project work package 2 which includes structures for the identification, recording, evaluation and propagation of risk throughout the evolution of network enterprise.

I would like to ask you to assist me in this study; by completing the attached questionnaire.

All of the information you kindly provide will be treated as completely confidential and it will not be possible for anyone to identify the source of information you supply.

I hope the questionnaire will only take 5-10 minutes of your time to fill out. Your cooperation is highly appreciated and will contribute to the success of this study. If you have any questions or concerns, please contact me awamlehm@coventry.ac.uk or my supervisor Prof. Keith Popplewell cex393@coventry.ac.uk

Thank you

Mohammad Alawamleh

Based on a literature review I identified the followed risks; the potential results of these risks are failure to meet delivery time, cost and quality targets or total failure for the collaboration.

1-Lack of trust:

The degree to which one partner trusts another is the measure of belief in the honesty, benevolence and competence of the other partner. We have problems if a virtual organisation partners do not trust each other, they will not share sensitive information and IPR, will not agree about splitting the money and will not work as they should to support the collaboration.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

2-Inadequate collaboration agreement:

The agreement between partners entering into the collaboration is not clear enough or the text is not sufficient.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

3-Heterogeneity of partners:

Heterogeneity means the partners incompatibility between system (hardware and operating system), syntax (different languages and data representations), structure (data model) and semantic (meaning of terms).

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

4-Ontology differences:

This problem occurs when two similar words mean two different thing or worse two different words mean the same thing when used by different partners.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

5-Structure and design

The dynamic structure of Virtual Organisation lacks the ability to synchronise parallel activities through failure to distribute responsibilities, tasks, rules, who report to whom (whose is charge) and span of control (the ability of the phase leader to manage the rest of the partners, the right of making decision and its affect on the whole of the network).Elements of structure and design may include centralisation, decentralisation, specialisation (division of labour), span of control and formalisation.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

6-Loss of communication:

Virtual Organisation variation and changing structure leads to loss of communication where less communications means more uncertainty.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

7-Culture:

A Virtual Organisation is a compression of several cultures. These different cultures lead to problems of incompatibility between processes and miscommunication.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

8-Bidding for several Virtual Organisations at the same time:

Partners may apply to collaborate in several Virtual Organisations at the same times where this partner capacity is insufficient to support all of these collaborations if all are successful.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

9-Information sharing:

Information sharing is vital for collaboration where decreasing information visibility in the virtual organisation increases the risks including the non-availability of catalogues with normalised and updated profiles of organisations.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

10-Top management commitment:

Weak participation by the highest level executives in a specific critical decision point in virtual organisation formation or operating maximises the risks.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

11-Knowledge about risks:

The absence of knowledge about the risks which may occur in the collaboration increase the chance for these risks to appear and maximise their impact.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

12-Wrong partner selection:

Incompatible objectives, strategies, culture, core competencies and capabilities are not complementary.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

13-Geographic location:

The geographic locations of different partners may increase the risk in Virtual Organisation where there is a direct correlation between risk and distance between different partners and some geographic locations may present more problem (political, legal) than others.

Importance: ☐Very Low ☐Low ☐Medium ☐High ☐Very high

Confident about answer: ☐Low ☐Medium ☐ High

14-Any other sources?

Thank you for completing this. I hope you will be able to contribute to later stages of this study too, but if you prefer not to receive any further requests, please indicate in the box below.

☐ I do not wish to participate further.

Please return the complete questionnaire to me at: awamlehm@coventry.ac.uk

Appendix 2

INTEROP-VLab Announcement

Dear Partners,

The Coventry University , partner of the INTEROP-VLab UK Pole, is supervising a study conducted by a PhD to investigate the risks in forming and operating Virtual Organisation collaboration.

The research title of the PhD research student is: Collaboration Risk Evaluation and Management for SMEs. This work is closely related to the SYNERGY project work package 2 which includes structures for the identification, recording, evaluation and propagation of risk throughout the evolution of network enterprise.

INTEROP-VLab proposes you to answer two questionnaires (about 30 min) and at the end of the study to publish the results on the INTEROP-VLab platform.
In the first level of this study, the risks sources which affect the Virtual Organisation based on a literature review and experts judgement are identified.

You are asked to participate in this second and final stage of the study, by completing two questionnaires through the following links:

1. http://ism.questionpro.com/
2. http://anp.questionpro.com/

The first questionnaire studies the relationships between risk sources and the second one weights the importance of these risk sources.
All of the information you kindly provide will be treated as completely confidential and it will not be possible for anyone to identify the source of information you supply.

If you have any questions or concerns, please contact Mohammad Alawamleh , PhD student at the Engineering Manufacture and Management department (awamlehm@coventry.ac.uk) or his supervisor Prof. Keith Popplewell (cex393@coventry.ac.uk)

Your cooperation is highly appreciated and will contribute to the success of this study. Thank you for your interest!

Cathy LIEU
INTEROP-VLab
Assistant Manager,
in charge of the communication
www.interop-vlab.eu

Phone: 00 33 (0)5 40 00 37 52
Fax: 00 33 (0)5 40 00 31 32

You are invited to participate in our survey "**Risk sources in Virtual Organization relations**". It will take approximately 20 minutes to complete the questionnaire.
This questionnaire is studying the relationships between risk sources in Virtual Organisation.
Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for us to learn your opinions.

Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Mohammad Alawamleh by email at awamlehm@coventry.ac.uk.

Explanation of the risk sources in the Virtual Organisation:

Based on a literature review and experts opinions the following risks have been identified; the potential results of these risks are failure to meet delivery time, cost and quality targets or total failure for the collaboration.

1-Lack of trust:
The degree to which one partner trusts another is the measure of belief in the honesty, benevolence and competence of the other partner. We have problems if a virtual organization partners do not trust each other, they will not share sensitive information and IPR, will not agree about splitting the money and will not work as they should to support the collaboration.

2-Inadequate collaboration agreement:
The agreement between partners entering into the collaboration is not clear enough or the text is not sufficient.

3-Heterogeneity of partners:
Heterogeneity means the partners incompatibility between system (hardware and operating system), syntax (different languages and data representations), structure (data model) and semantic (meaning of terms).

4-Ontology differences:
This problem occurs when two similar words mean two different thing or worse two different words mean the same thing when used by different partners.

5-Structure and design:
The dynamic structure of Virtual Organisation lacks the ability to synchronise parallel activities through failure to distribute responsibilities, tasks, rules , who report to whom (whose is charge) and span of control (the ability of the phase leader to manage the rest of the partners , the right of making decision and its affect on the whole of the network). Elements of structure and design may include centralisation, decentralisation, specialisation (division of labour), span of control and formalisation.

6-Loss of communication:
Virtual Organisation variation and changing structure leads to loss of communication where less communications means more uncertainty.

7-Culture differences:
A Virtual Organisation is a compression of several cultures. These different cultures lead to problems of incompatibility between processes and miscommunication.

8-Bidding for several Virtual Organisations at the same time:
Partners may apply to collaborate in several Virtual Organisations at the same times where this partner capacity is insufficient to support all of these collaborations if all are successful.

9-Lack of information sharing:
Information sharing is vital for collaboration where decreasing information visibility in the virtual organisation increases the risks including the non-availability of catalogues with normalized and updated profiles of organisations.

10-Lack of top management commitment:

Weak participation by the highest level executives in a specific critical decision point in virtual organisation formation or operating maximises the risks.

11-Lack of Knowledge about risks:

The absence of knowledge about the risks which may occur in the collaboration increase the chance for these risks to appear and maximise their impact.

12-Wrong partner selection:

Incompatible objectives, strategies, culture, core competencies and capabilities are not complementary.

13-Geographic location:

The geographic locations of different partners may increase the risk in Virtual Organisation where there is a direct correlation between risk and distance between different partners and some geographic locations may present more problem (political, legal) than others.

Thank you very much for your time and support.

1. Relationship between "Lack of Trust" and "Inadequate Collaboration Agreement".	
V : Lack of trust risk will increase inadequate collaboration agreement risk	4
A : Inadequate collaboration agreement risk will increase lack of trust risk	35
X : Lack of trust risk and inadequate collaboration agreement risk will increase each other	6
O : Lack of trust risk and inadequate collaboration agreement risk are unrelated	0
2. Relationship between "Lack of Trust" and "Heterogeneity of Partners" .	
V : Lack of trust risk will increase heterogeneity of partners risk	2
A : Heterogeneity of partners risk will increase lack of trust risk	36
X : Lack of trust risk and heterogeneity of partners risk will increase each other	3
O : Lack of trust risk and heterogeneity of partners risk are unrelated	4
3. Relationship between "Lack of Trust" and "Ontology Differences".	
V : Lack of trust risk will increase ontology differences risk	2
A : Ontology differences risk will increase lack of trust risk	33
X : Lack of trust risk and ontology differences risk will increase each other	2
O : Lack of trust risk and ontology differences risk are unrelated	8
4. Relationship between "Lack of Trust" and Structure and Design".	
V : Lack of trust risk will increase structure and design risk	3
A : Structure and design risk will increase lack of trust risk	40
X : Lack of trust risk and Structure and design risk will increase each other	1
O : Lack of trust risk and Structure and design risk are unrelated	1
5. Relationship between "Lack of Trust" and "Loss of Communication".	
V : Lack of trust risk will increase loss of communication risk	5
A : Loss of communication will increase lack of trust risk	32
X : Lack of trust risk and loss of communication risk will increase each other	8
O : Lack of trust risk and loss of communication risk are unrelated	0
6. Relationship between "Lack of Trust" and "Culture differences".	
V : Lack of trust risk will increase culture differences risk	2
A : Culture differences will increase lack of trust risk	39
X : Lack of trust risk and culture differences risk will increase each other	4
O : Lack of trust risk and culture differences risk are unrelated	0
7. Relationship between "Lack of Trust" and "Bidding for Several VO at the Same Time".	
V : Lack of trust risk will increase bidding for several VO at the same time risk	31
A : Bidding for several VO at the same time will increase lack of trust risk	5
X : Lack of trust risk and bidding for several VO at the same time risk will increase each other	4
O : Lack of trust risk and bidding for several VO at the same time risk are unrelated	5
8. Relationship between "Lack of Trust" and "Lack of Information Sharing".	
V : Lack of trust risk will increase lack of information sharing risk	2
A : Lack of information sharing will increase lack of trust risk	3
X : Lack of trust risk and lack of information sharing risk will increase each other	40
O : Lack of trust risk and lack of information sharing risk are unrelated	0
9. Relationship between "Lack of Trust" and "Lack of Top Management Commitment".	
V : Lack of trust risk will increase lack of top management commitment risk	5
A : Lack of top management commitment will increase lack of trust risk	5
X : Lack of trust risk and lack of top management commitment risk will increase each other	33

O : Lack of trust risk and lack of top management commitment are unrelated	2
10. Relationship between "Lack of Trust and "Lack of knowledge about risks".	
V : Lack of trust risk will increase lack of knowledge about risks risk	4
A : Lack of knowledge about risks will increase lack of trust risk	5
X : Lack of trust risk and lack of knowledge about risks risk will increase each other	5
O : Lack of trust risk and lack of knowledge about risks risk are unrelated	31
11. Relationship between "Lack of Trust and "Wrong Partner Selection".	
V : Lack of trust risk will increase wrong partner selection risk	38
A : Wrong partner selection will increase lack of trust risk	2
X : Lack of trust risk and wrong partner selection risk will increase each other	5
O : Lack of trust risk and wrong partner selection risk are unrelated	0
12. Relationship between "Lack of Trust" and "Geographic Location".	
V: Lack of trust risk will increase geographic location risk	0
A: Geographic location will increase lack of trust risk	40
X: Lack of trust risk and geographic location risk will increase each other	3
O: Lack of trust risk and geographic location risk are unrelated	2
13. Relationship between "Inadequate Collaboration Agreement" and "Heterogeneity of Partners".	
V : Inadequate collaboration agreement risk will increase heterogeneity of partners risk	4
A : Heterogeneity of partners risk will inadequate collaboration agreement risk	4
X : Inadequate collaboration agreement risk and heterogeneity of partners risk will increase each other	7
O : Inadequate collaboration agreement risk and heterogeneity of partners risk are unrelated	30
14. Relationship between "Inadequate Collaboration Agreement" and "Ontology Differences".	
V : Inadequate collaboration agreement risk will increase ontology differences risk	3
A : ontology differences risk will increase inadequate collaboration agreement risk	32
X : Inadequate collaboration agreement risk and ontology differences risk will increase each other	8
O : Inadequate collaboration agreement risk and ontology differences risk are unrelated	2
15. Relationship between "Inadequate collaboration agreement" and "Structure and Design".	
V : Inadequate collaboration agreement risk will increase structure and design risk	2
A : Structure and design risk will increase inadequate collaboration agreement risk	8
X : Inadequate collaboration agreement risk and structure and design risk will increase each other	4
O : Inadequate collaboration agreement risk and structure and design risk are unrelated	31
16. Relationship between "Inadequate Collaboration Agreement" and "Loss of Communication".	
V : Inadequate collaboration agreement risk will increase loss of communication risk	30
A : Loss of communication will increase inadequate collaboration agreement risk	6
X : Inadequate collaboration agreement risk and loss of communication risk will increase each other	9
O : Inadequate collaboration agreement risk and loss of communication risk are unrelated	0
17. Relationship between "Inadequate Collaboration Agreement" and "Culture differences".	
V : Inadequate collaboration agreement risk will increase culture differences risk	0
A : Culture differences will increase inadequate collaboration agreement risk	8
X : Inadequate collaboration agreement risk and culture differences risk will increase each other	2
O : Inadequate collaboration agreement risk and culture differences risk are unrelated	35
18. Relationship between "Inadequate Collaboration Agreement" and "Bidding for Several VO at the Same Time".	
V : Inadequate collaboration agreement risk will increase bidding for several VO at the same time risk	32
A : Bidding for several VO at the same time will increase inadequate collaboration agreement risk	3
X : Inadequate collaboration agreement risk and bidding for several VO at the same time risk will increase each other	7
O : Inadequate collaboration agreement risk and bidding for several VO at the same time risk are unrelated	3
19. Relationship between "Inadequate Collaboration Agreement" and "Lack of Information Sharing".	
V : Inadequate collaboration agreement risk will increase lack of information sharing risk	39
A : Lack of information sharing will increase inadequate collaboration agreement risk	2
X : Inadequate collaboration agreement risk and lack of information sharing risk will increase each other	2
O : Inadequate collaboration agreement risk and lack of information sharing risk are unrelated	2
20. Relationship between "Inadequate Collaboration Agreement" and "Lack of Top Management Commitment".	
V : Inadequate collaboration agreement risk will increase lack of top management commitment risk	36
A : Lack of top management commitment will increase Inadequate collaboration agreement risk	3
X : Inadequate collaboration agreement risk and lack of top management commitment risk will increase each other	4
O : Inadequate collaboration agreement risk and lack of top management commitment are unrelated	2
21. Relationship between "Inadequate Collaboration Agreement" and "Lack of Knowledge about Risks".	
V : Inadequate collaboration agreement risk will increase lack of knowledge about risks risk	35
A : Lack of knowledge about risks will increase inadequate collaboration agreement risk	5
X : Inadequate collaboration agreement risk and lack of knowledge about risks risk will increase each other	4

O : Inadequate collaboration agreement risk and lack of knowledge about risks risk are unrelated	1
22. Relationship between "Inadequate Collaboration Agreement and "Wrong Partner Selection" .	
V : Inadequate collaboration agreement risk will increase wrong partner selection risk	33
A : Wrong partner selection will increase inadequate collaboration agreement risk	2
X : Inadequate collaboration agreement risk and wrong partner selection risk will increase each other	6
O : Inadequate collaboration agreement risk and wrong partner selection risk are unrelated	4
23. Relationship between "Inadequate Collaboration Agreement and "Geographic Location".	
V: Inadequate collaboration agreement risk will increase geographic location risk	4
A: Geographic location will increase inadequate collaboration agreement risk	2
X: Inadequate collaboration agreement risk and geographic location risk will increase each other	4
O: Inadequate collaboration agreement risk and geographic location risk are unrelated	35
24. Relationship between "Heterogeneity of Partners" and "Ontology Differences".	
V : Heterogeneity of partners risk will increase ontology differences risk	0
A : Ontology differences risk will increase heterogeneity of partners risk	12
X : Heterogeneity of partners risk and ontology differences risk will increase each other	3
O : Heterogeneity of partners risk and ontology differences risk are unrelated	30
25. Relationship between "Heterogeneity of Partners and "Structure and Design".	
V : Heterogeneity of partners risk will increase structure and design risk	39
A : Structure and design risk will increase heterogeneity of partners risk	2
X : Heterogeneity of partners risk and structure and design risk will increase each other	3
O : Heterogeneity of partners risk and structure and design risk are unrelated	1
26. Relationship between "Heterogeneity of Partners" and "Loss of Communication".	
V : Heterogeneity of partners risk will increase loss of communication risk	38
A : Loss of communication will increase heterogeneity of partners risk	2
X : Heterogeneity of partners risk and loss of communication risk will increase each other	5
O : Heterogeneity of partners risk and loss of communication risk are unrelated	0
27. Relationship between "Heterogeneity of Partners and "Culture differences".	
V : Heterogeneity of partners risk will increase culture differences risk	3
A : Culture differences will increase heterogeneity of partners risk	7
X : Heterogeneity of partners risk and culture differences risk will increase each other	4
O : Heterogeneity of partners risk and culture differences risk are unrelated	31
28. Relationship between "Heterogeneity of Partners" and "Bidding for Several VO at the Same Time".	
V : Heterogeneity of partners risk will increase bidding for several VO at the same time risk	38
A : Bidding for several VO at the same time will increase heterogeneity of partners risk	2
X : Heterogeneity of partners risk and bidding for several VO at the same time risk will increase each other	4
O : Heterogeneity of partners risk and bidding for several VO at the same time risk are unrelated	1
29. Relationship between "Heterogeneity of Partners" and "Lack of Information Sharing".	
V : Heterogeneity of partners risk will increase lack of information sharing risk	34
A : Lack of information sharing will increase heterogeneity of partners risk	6
X : Heterogeneity of partners risk and lack of information sharing risk will increase each other	5
O : Heterogeneity of partners risk and lack of information sharing risk are unrelated	0
30. Relationship between "Heterogeneity of Partners" and "Lack of Top Management Commitment".	
V : Heterogeneity of partners risk will increase lack of top management commitment risk	32
A : Lack of top management commitment will increase heterogeneity of partners risk	4
X : Heterogeneity of partners risk and lack of top management commitment risk will increase each other	7
O : Heterogeneity of partners risk and lack of top management commitment are unrelated	2
31. Relationship between "Heterogeneity of Partners" and "Lack of Knowledge about Risks".	
V : Heterogeneity of partners risk will increase lack of knowledge about risks risk	32
A : Lack of knowledge about risks will increase heterogeneity of partners risk	7
X : Heterogeneity of partners risk and lack of knowledge about risks risk will increase each other	3
O : Heterogeneity of partners risk and lack of knowledge about risks risk are unrelated	3
32. Relationship between "Heterogeneity of Partners and "Wrong Partner Selection".	
V : Heterogeneity of partners risk will increase wrong partner selection risk	37
A : Wrong partner selection will increase heterogeneity of partners risk	2
X : Heterogeneity of partners risk and wrong partner selection risk will increase each other	4
O : Heterogeneity of partners risk and wrong partner selection risk are unrelated	2
33. Relationship between "Heterogeneity of Partners" and "Geographic Location".	
V: Heterogeneity of partners risk will increase geographic location risk	4
A: Geographic location will increase Heterogeneity of partners risk	4
X: Heterogeneity of partners risk and geographic location risk will increase each other	6
O: Heterogeneity of partners risk and geographic location risk are unrelated	31
34. Relationship between "Ontology Differences" and "Structure and Design".	
V : Ontology differences risk will increase structure and design risk	2
A : Structure and design risk will increase Ontology differences risk	4

X : Ontology differences risk and structure and design risk will increase each other	6
O : Ontology differences risk and structure and design risk are unrelated	33
35. Relationship between "Ontology Differences" and "Loss of Communication".	
V : Ontology differences risk will increase loss of communication risk	37
A : Loss of communication will increase ontology differences risk	3
X : Ontology differences risk and loss of communication risk will increase each other	5
O : Ontology differences risk and loss of communication risk are unrelated	0
36. Relationship between "Ontology Differences" and "Culture differences".	
V : Ontology differences risk will increase culture differences risk	0
A : Culture differences will increase ontology differences risk	8
X : Ontology differences risk and culture differences risk will increase each other	2
O : Ontology differences risk and culture differences risk are unrelated	35
37. Relationship between "Ontology Differences" and "Bidding for Several VO at the Same Time".	
V : Ontology differences risk will increase bidding for several VO at the same time risk	30
A : Bidding for several VO at the same time will increase ontology differences risk	5
X : Ontology differences risk and bidding for several VO at the same time risk will increase each other	4
O : Ontology differences risk and bidding for several VO at the same time risk are unrelated	6
38. Relationship between "Ontology Differences and "Lack of Information Sharing".	
V : Ontology differences risk will increase lack of information sharing risk	32
A : Lack of information sharing will increase ontology differences risk	4
X : Ontology differences risk and lack of information sharing risk will increase each other	6
O : Ontology differences risk and lack of information sharing risk are unrelated	3
39. Relationship between "Ontology Differences" and "Lack of Top Management Commitment".	
V : Ontology differences risk will increase lack of top management commitment risk	31
A : Lack of top management commitment will increase ontology differences risk	3
X : Ontology differences risk and lack of top management commitment risk will increase each other	6
O : Ontology differences risk and lack of top management commitment are unrelated	5
40. Relationship between "Ontology Differences" and "Lack of Knowledge about Risks".	
V : Ontology differences risk will increase lack of knowledge about risks risk	31
A : Lack of knowledge about risks will increase ontology differences risk	3
X : Ontology differences risk and lack of knowledge about risks risk will increase each other	3
O : Ontology differences risk and lack of knowledge about risks risk are unrelated	8
41. Relationship between "Ontology Differences" and "Wrong Partner Selection".	
V : Ontology differences risk will increase wrong partner selection risk	39
A : Wrong partner selection will increase ontology differences risk	1
X : Ontology differences risk and wrong partner selection risk will increase each other	5
O : Ontology differences risk and wrong partner selection risk are unrelated	0
42. Relationship between "Ontology Differences" and "Geographic Location".	
V: Ontology differences risk will increase geographic location risk	0
A: Geographic location will increase ontology differences risk	10
X: Ontology differences risk and geographic location risk will increase each other	4
O: Ontology differences risk and geographic location risk are unrelated	31
43. Relationship between "Structure and design" and "Loss of Communication".	
V : Structure and design risk will increase loss of communication risk	39
A : Loss of communication will increase Structure and design risk	2
X : Structure and design risk and loss of communication risk will increase each other	4
O : Structure and design risk and loss of communication risk are unrelated	0
44. Relationship between "Structure and design" and "Culture differences".	
V : Structure and design risk will increase culture differences risk	3
A : Culture differences will increase structure and design risk	9
X : Structure and design risk and culture differences risk will increase each other	3
O : Structure and design risk and culture differences risk are unrelated	30
45. Relationship between "Structure and design" and "Bidding for Several VO at the Same Time".	
V : Structure and design risk will increase bidding for several VO at the same time risk	31
A : Bidding for several VO at the same time will increase Structure and design risk	4
X : Structure and design risk and bidding for several VO at the same time risk will increase each other	8
O : Structure and design risk and bidding for several VO at the same time risk are unrelated	2
46. Relationship between "Structure and Design and "Lack of Information Sharing".	
V : Structure and design risk will increase lack of information sharing risk	38
A : Lack of information sharing will increase structure and design risk	2
X : Structure and design risk and lack of information sharing risk will increase each other	5
O : Structure and design risk and lack of information sharing risk are unrelated	0
47. Relationship between "Structure and Design" and "Lack of Top Management Commitment".	
V : Structure and design risk will increase lack of top management commitment risk	34

A : Lack of top management commitment will increase structure and design risk	4
X : Structure and design risk and lack of top management commitment risk will increase each other	5
O : Structure and design risk and lack of top management commitment are unrelated	2
48. Relationship between "Structure and Design" and "Lack of Knowledge about Risks".	
V : Structure and design risk will increase lack of knowledge about risks risk	33
A : Lack of knowledge about risks will increase structure and design risk	5
X : Structure and design risk and lack of knowledge about risks risk will increase each other	4
O : Structure and design risk and lack of knowledge about risks risk are unrelated	3
49. Relationship between "Structure and Design" and "Wrong Partner Selection".	
V : Structure and design risk will increase wrong partner selection risk	33
A : Wrong partner selection will increase structure and design risk	5
X : Structure and design risk and wrong partner selection risk will increase each other	4
O : Structure and design risk and wrong partner selection risk are unrelated	3
50. Relationship between "Structure and Design and "Geographic Location".	
V: Structure and design risk will increase geographic location risk	3
A: Geographic location will increase structure and design risk	4
X: Structure and design risk and geographic location risk will increase each other	7
O: Structure and design risk and geographic location risk are unrelated	31
51. Relationship between "Loss of Communication" and "Culture Differences ".	
V : Loss of communication risk will increase culture differences risk	4
A : Culture differences will increase Loss of communication risk	35
X : Loss of communication risk and culture differences risk will increase each other	3
O : Loss of communication risk and culture differences risk are unrelated	3
52. Relationship between "Loss of Communication" and "Bidding for Several VO at the Same Time".	
V : Loss of communication risk will increase bidding for several VO at the same time risk	32
A : Bidding for several VO at the same time will increase Loss of communication risk	4
X : Loss of communication risk and bidding for several VO at the same time risk will increase each other	7
O : Loss of communication risk and bidding for several VO at the same time risk are unrelated	2
53. Relationship between "Loss of Communication" and "Lack of Information Sharing".	
V : Loss of communication risk will increase lack of information sharing risk	34
A : Lack of information sharing will increase loss of communication risk	4
X : Loss of communication risk and lack of information sharing risk will increase each other	7
O : Loss of communication risk and lack of information sharing risk are unrelated	0
54. Relationship between "Loss of Communication" and "Lack of Top management Commitment".	
V : Loss of communication risk will increase lack of top management commitment risk	33
A : Lack of top management commitment will increase loss of communication risk	4
X : Loss of communication and lack of top management commitment risk will increase each other	8
O : Loss of communication risk and lack of top management commitment are unrelated	0
55. Relationship between "Loss of Communication" and "Lack of Knowledge about Risks".	
V : Loss of communication risk will increase lack of knowledge about risks risk	31
A : Lack of knowledge about risks will increase loss of communication risk	5
X : Loss of communication risk and lack of knowledge about risks risk will increase each other	7
O : Loss of communication risk and lack of knowledge about risks risk are unrelated	2
56. Relationship between "Loss of Communication" and "Wrong Partner Selection".	
V : Loss of communication risk will increase wrong partner selection risk	34
A : Wrong partner selection will increase loss of communication risk	6
X : Loss of communication risk and wrong partner selection risk will increase each other	5
O : Loss of communication risk and wrong partner selection risk are unrelated	0
57. Relationship between "Loss of Communication" and "Geographic Location".	
V: Loss of communication risk will increase geographic location risk	9
A: Geographic location will increase loss of communication risk	34
X: Loss of communication risk and geographic location risk will increase each other	1
O: Loss of communication risk and geographic location risk are unrelated	1
58. Relationship between "Culture Differences" and "Bidding for Several VO at the Same Time".	
V : Culture differences risk will increase bidding for several VO at the same time risk	33
A : Bidding for several VO at the same time will increase Culture differences risk	1
X : Culture differences risk and bidding for several VO at the same time risk will increase each other	8
O : Culture differences risk and bidding for several VO at the same time risk are unrelated	3
59. Relationship between "Culture Differences" and "Lack of Information Sharing".	
V : Culture differences risk will increase lack of information sharing risk	40
A : Lack of information sharing will increase Culture differences risk	0
X : Culture differences risk and lack of information sharing risk will increase each other	4
O : Culture differences risk and lack of information sharing risk are unrelated	1
60. Relationship between "Culture Differences" and "Lack of Top Management Commitment".	

V : Culture differences risk will increase lack of top management commitment risk	36
A : Lack of top management commitment will increase culture differences risk	0
X : Culture differences and lack of top management commitment risk will increase each other	9
O : Culture differences risk and lack of top management commitment are unrelated	0
61. Relationship between "Culture differences" and "Lack of Knowledge about Risks".	
V : Culture differences risk will increase lack of knowledge about risks risk	32
A : Lack of knowledge about risks will increase culture differences risk	1
X : Culture differences and lack of knowledge about risks risk will increase each other	8
O : Culture differences risk and lack of knowledge about risks risk are unrelated	4
62. Relationship between "Culture differences" and "Wrong Partner Selection".	
V : Culture differences risk will increase wrong partner selection risk	35
A : Wrong partner selection will increase culture differences risk	2
X : Culture differences risk and wrong partner selection risk will increase each other	7
O : Culture differences risk and wrong partner selection risk are unrelated	1
63. Relationship between "Culture differences" and "Geographic Location".	
V: Culture differences risk will increase geographic location risk	2
A: Geographic location will increase culture differences risk	2
X: Culture differences risk and geographic location risk will increase each other	12
O: Culture differences risk and geographic location risk are unrelated	29
64. Relationship between "Bidding for Several VO at the Same Time Risk and "Lack of Information Sharing".	
V : Bidding for several VO at the same time risk will increase lack of information sharing risk	4
A : Lack of information sharing will increase Bidding for several VO at the same time risk	6
X : Bidding for several VO at the same time risk and lack of information sharing risk will increase each other	5
O : Bidding for several VO at the same time risk and lack of information sharing risk are unrelated	30
65. Relationship between "Bidding for Several VO at the Same Time" and "Lack of Top Management Commitment".	
V : Bidding for several VO at the same time risk will increase lack of top management commitment risk	4
A : Lack of top management commitment will increase bidding for several VO at the same time risk	33
X : Bidding for several VO at the same time and lack of top management commitment risk will increase each other	6
O : Bidding for several VO at the same time risk and lack of top management commitment are unrelated	2
66. Relationship between "Bidding for Several VO at the Same Time" and "Lack of Knowledge about Risks".	
V : Bidding for several VO at the same time risk will increase lack of knowledge about risks risk	35
A : Lack of knowledge about risks will increase bidding for several VO at the same time e risk	4
X : Bidding for several VO at the same time and lack of knowledge about risks risk will increase each other	3
O : Bidding for several VO at the same time risk and lack of knowledge about risks risk are unrelated	3
67. Relationship between "Bidding for Several VO at the Same Time" and "Wrong Partner Selection".	
V : Bidding for several VO at the same time risk will increase wrong partner selection risk	34
A : Wrong partner selection will increase bidding for several VO at the same time risk	4
X : Bidding for several VO at the same time risk and wrong partner selection risk will increase each other	7
O : Bidding for several VO at the same time risk and wrong partner selection risk are unrelated	0
68. Relationship between "Bidding for Several VO at the Same Time" and "Geographic Location".	
V: Bidding for several VO at the same time risk will increase geographic location risk	1
A: Geographic location will increase bidding for several VO at the same time risk	37
X: Bidding for several VO at the same time risk and geographic location risk will increase each other	6
O: Bidding for several VO at the same time risk and geographic location risk are unrelated	1
69. Relationship between "Lack of information sharing" and "Lack of Top management Commitment".	
V : Lack of information sharing risk will increase lack of top management commitment risk	2
A : Lack of top management commitment will increase lack of information sharing risk	3
X : Lack of information sharing and lack of top management commitment risk will increase each other	40
O : Lack of information sharing risk and lack of top management commitment are unrelated	0
70. Relationship between "Lack of Information Sharing" and "Lack of Knowledge about Risks".	
V : Lack of information sharing risk will increase lack of knowledge about risks risk	41
A : Lack of knowledge about risks will increase lack of information sharing risk	2
X : Lack of information sharing and lack of knowledge about risks risk will increase each other	2
O : Lack of information sharing risk and lack of knowledge about risks risk are unrelated	0
71. Relationship between "Lack of Information Sharing" and "Wrong Partner Selection".	
V : Lack of information sharing risk will increase wrong partner selection risk	34
A : Wrong partner selection will increase lack of information sharing risk	3
X : Lack of information sharing risk and wrong partner selection risk will increase each other	6
O : Lack of information sharing risk and wrong partner selection risk are unrelated	2
72. Relationship between "Lack of Information Sharing" and "Geographic Location".	

V: Lack of information sharing risk will increase geographic location risk	0
A: Geographic location will increase lack of information sharing risk	39
X: Lack of information sharing risk and geographic location risk will increase each other	5
O: Lack of information sharing risk and geographic location risk are unrelated	1
73. Relationship between "Lack of Top Management Commitment" and "Lack of Knowledge about Risks".	
V : Lack of top management commitment risk will increase lack of knowledge about risks risk	2
A : Lack of knowledge about risks will increase lack of top management commitment risk	4
X : Lack of top management commitment and lack of knowledge about risks risk will increase each other	9
O : Lack of top management commitment risk and lack of knowledge about risks risk are unrelated	30
74. Relationship between "Lack of Top Management Commitment" and "Wrong Partner Selection".	
V : Lack of top management commitment risk will increase wrong partner selection risk	38
A : Wrong partner selection will increase lack of top management commitment risk	2
X : Lack of top management commitment risk and wrong partner selection risk will increase each other	3
O : Lack of top management commitment risk and wrong partner selection risk are unrelated	2
75. Relationship between "Lack of Top Management Commitment" and "Geographic Location".	
V: Lack of top management commitment risk will increase geographic location risk	0
A: Geographic location will increase lack of top management commitment risk	32
X: Lack of top management commitment risk and geographic location risk will increase each other	3
O: Lack of top management commitment risk and geographic location risk are unrelated	10
76. Relationship between "Lack of Knowledge about Risks" and "Wrong Partner Selection".	
V : Lack of knowledge about risks risk will increase wrong partner selection risk	38
A : Wrong partner selection will increase lack of knowledge about risks risk	2
X : Lack of knowledge about risks risk and wrong partner selection risk will increase each other	5
O : Lack of knowledge about risks risk and wrong partner selection risk are unrelated	0
77. Relationship between "Lack of Knowledge about Risks" and "Geographic Location".	
V: Lack of knowledge about risks risk will increase geographic location risk	0
A: Geographic location will increase lack of knowledge about risks risk	34
X: Lack of knowledge about risks risk and geographic location risk will increase each other	2
O: Lack of knowledge about risks risk and geographic location risk are unrelated	9
78. Relationship between "Wrong Partner Selection" and "Geographic Location".	
V: Wrong partner selection risk will increase geographic location risk	0
A: Geographic location will increase wrong partner selection risk	34
X: Wrong partner selection risk and geographic location risk will increase each other	1
O: Wrong partner selection risk and geographic location risk are unrelated	10
How much are you confident about your answers?	
1. Low	5
2. Medium	18
3. High	22
Would you like to add any comment or expand on any answer?	

You are invited to participate in our survey "**Risk sources in Virtual Organisation weighting**". It will take approximately 20 minutes to complete the questionnaire.
This questionnaire is studying the importance of risk sources in Virtual Organisation through pairwise comparison. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for us to learn your opinions.

Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Mohammad Alawamleh by email at awamlehm@coventry.ac.uk.
Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Mohammad Alawamleh by email at awamlehm@coventry.ac.uk.

Explanation of the risk sources in the Virtual Organisation:

Based on a literature review and experts opinions the following risks have been identified; the potential results of these risks are failure to meet delivery time, cost and quality targets or total failure for the collaboration.

1-Lack of trust:
The degree to which one partner trusts another is the measure of belief in the honesty, benevolence and competence of the other partner. We have problems if a virtual organization partners do not trust each other, they will not share sensitive information and IPR, will not agree about splitting the money and will not work as they should to support the collaboration.

2-Inadequate collaboration agreement:
The agreement between partners entering into the collaboration is not clear enough or the text is not sufficient.

3-Heterogeneity of partners:
Heterogeneity means the partners incompatibility between system (hardware and operating system), syntax (different languages and data representations), structure (data model) and semantic (meaning of terms).

4-Ontology differences:
This problem occurs when two similar words mean two different thing or worse two different words mean the same thing when used by different partners.

5-Structure and design:
The dynamic structure of Virtual Organisation lacks the ability to synchronise parallel activities through failure to distribute responsibilities, tasks, rules , who report to whom (whose is charge) and span of control (the ability of the phase leader to manage the rest of the partners , the right of making decision and its affect on the whole of the network). Elements of structure and design may include centralisation, decentralisation, specialisation (division of labour), span of control and formalisation.

6-Loss of communication:
Virtual Organisation variation and changing structure leads to loss of communication where less communications means more uncertainty.

7-Culture differences:
A Virtual Organisation is a compression of several cultures. These different cultures lead to problems of incompatibility between processes and miscommunication.

8-Bidding for several Virtual Organisations at the same time:
Partners may apply to collaborate in several Virtual Organisations at the same times where this partner capacity is insufficient to support all of these collaborations if all are successful.

9-Lack of information sharing:

Information sharing is vital for collaboration where decreasing information visibility in the virtual organisation increases the risks including the non-availability of catalogues with normalized and updated profiles of organisations.

10-Lack of top management commitment:

Weak participation by the highest level executives in a specific critical decision point in virtual organisation formation or operating maximises the risks.

11-Lack of Knowledge about risks:

The absence of knowledge about the risks which may occur in the collaboration increase the chance for these risks to appear and maximise their impact.

12-Wrong partner selection:

Incompatible objectives, strategies, culture, core competencies and capabilities are not complementary.

13-Geographic location:

The geographic locations of different partners may increase the risk in Virtual Organisation where there is a direct correlation between risk and distance between different partners and some geographic locations may present more problem (political, legal) than others.

Thank you very much for your time and support.

1. "Lack of Trust" and "Inadequate Collaboration Agreement" comparison.	
5:1 Lack of trust" absolutely more important" than inadequate collaboration agreement	3
4:1 Lack of trust" very strongly more important" than inadequate collaboration agreement	5
3:1 Lack of trust" essentially more important" than inadequate collaboration agreement	30
2:1 Lack of trust" weakly more important" than inadequate collaboration agreement	7
1:1 Lack of trust" equally important " inadequate collaboration agreement	0
1:2 Inadequate collaboration agreement "weakly more important" than lack of trust	0
1:3 Inadequate collaboration agreement "essentially more important" than lack of trust	0
1:4 Inadequate collaboration agreement "very strongly more important" than lack of trust	0
1:5 Inadequate collaboration agreement "absolutely more important" than lack of trust	0
2. "Lack of Trust" and "Heterogeneity of Partners" comparison.	
5:1 Lack of trust" absolutely more important" than heterogeneity of partners	7
4:1 Lack of trust" very strongly more important" than heterogeneity of partners	27
3:1 Lack of trust" essentially more important" than heterogeneity of partners	11
2:1 Lack of trust" weakly more important" than heterogeneity of partners	0
1:1 Lack of trust" equally important "heterogeneity of partners	0
1:2 Heterogeneity of partners "weakly more important" than lack of trust	0
1:3 Heterogeneity of partners "essentially more important" than lack of trust	0
1:4 Heterogeneity of partners "very strongly more important" than lack of trust	0
1:5 Heterogeneity of partners "absolutely more important" than lack of trust	0
3. "Lack of Trust" and "Ontology Differences" comparison.	
5:1 Lack of trust" absolutely more important" than ontology differences	10
4:1 Lack of trust" very strongly more important" than ontology differences	23
3:1 Lack of trust" essentially more important" than ontology differences	7
2:1 Lack of trust" weakly more important" than ontology differences	5
1:1 Lack of trust" equally important "ontology differences	0
1:2 Ontology differences "weakly more important" than lack of trust	0
1:3 Ontology differences "essentially more important" than lack of trust	0
1:4 Ontology differences "very strongly more important" than lack of trust	0
1:5 Ontology differences "absolutely more important" than lack of trust	0
4. "Lack of Trust" and "Structure and Design" comparison.	
5:1 Lack of trust" absolutely more important" than structure and design	25
4:1 Lack of trust" very strongly more important" than structure and design	10
3:1 Lack of trust" essentially more important" than structure and design	5
2:1 Lack of trust" weakly more important" than structure and design	4
1:1 Lack of trust" equally important "structure and design	1
1:2 Structure and design "weakly more important" than lack of trust	0
1:3 Structure and design "essentially more important" than lack of trust	0
1:4 Structure and design "very strongly more important" than lack of trust	0
1:5 Structure and design "absolutely more important" than lack of trust	0
5. "Lack of Trust" and "Loss of Communication" comparison.	

5:1 Lack of trust “absolutely more important” than loss of communication	31
4:1 Lack of trust “very strongly more important” than loss of communication	5
3:1 Lack of trust “essentially more important” than loss of communication	4
2:1 Lack of trust “weakly more important” than loss of communication	1
1:1 Lack of trust “equally important “loss of communication	4
1:2 Loss of communication “weakly more important” than lack of trust	0
1:3 Loss of communication “essentially more important” than lack of trust	0
1:4 Loss of communication “very strongly more important” than lack of trust	0
1:5 Loss of communication “absolutely more important” than lack of trust	0
6. "Lack of Trust" and "Culture differences" comparison.	
5:1 Lack of trust “absolutely more important” than Culture differences	8
4:1 Lack of trust “very strongly more important” than Culture differences	4
3:1 Lack of trust “essentially more important” than Culture differences	5
2:1 Lack of trust “weakly more important” than Culture differences	28
1:1 Lack of trust “equally important “Culture differences	0
1:2 Culture differences “weakly more important” than lack of trust	0
1:3 Culture differences “essentially more important” than lack of trust	0
1:4 Culture differences “very strongly more important” than lack of trust	0
1:5 Culture differences “absolutely more important” than lack of trust	0
7. "Lack of Trust" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Lack of trust “absolutely more important” than bidding for several VO at the same time	6
4:1 Lack of trust “very strongly more important” than bidding for several VO at the same time	9
3:1 Lack of trust “essentially more important” than bidding for several VO at the same time	24
2:1 Lack of trust “weakly more important” than bidding for several VO at the same time	6
1:1 Lack of trust “equally important “bidding for several VO at the same time	0
1:2 Bidding for several VO at the same time “weakly more important” than lack of trust	0
1:3 Bidding for several VO at the same time “essentially more important” than lack of trust	0
1:4 Bidding for several VO at the same time “very strongly more important” than lack of trust	0
1:5 Bidding for several VO at the same time “absolutely more important” than lack of trust	0
8. "Lack of Trust" and "Lack of Information Sharing" comparison.	
5:1 Lack of trust “absolutely more important” than lack of information sharing	5
4:1 Lack of trust “very strongly more important” than lack of information sharing	4
3:1 Lack of trust “essentially more important” than lack of information sharing	9
2:1 Lack of trust “weakly more important” than lack of information sharing	26
1:1 Lack of trust “equally important “lack of information sharing	1
1:2 Lack of information sharing” weakly more important” than lack of trust	0
1:3 Lack of information sharing “essentially more important” than lack of trust	0
1:4 Lack of information sharing “very strongly more important” than lack of trust	0
1:5 Lack of information sharing “absolutely more important” than lack of trust	0
9. "Lack of Trust" and "Top Management Commitment" comparison.	
5:1 Lack of trust “absolutely more important” than top management commitment	9
4:1 Lack of trust “very strongly more important” than top management commitment	8
3:1 Lack of trust “essentially more important” than top management commitment	27
2:1 Lack of trust “weakly more important” than top management commitment	1
1:1 Lack of trust “equally important “top management commitment	0
1:2 Top management commitment “weakly more important” than lack of trust	0
1:3 Top management commitment “essentially more important” than lack of trust	0
1:4 Top management commitment “very strongly more important” than lack of trust	0
1:5 Top management commitment “absolutely more important” than lack of trust	0
10. "Lack of Trust" and "Lack of Knowledge about Risks" comparison.	
5:1 Lack of trust “absolutely more important” than lack of knowledge about risks	25
4:1 Lack of trust “very strongly more important” than lack of knowledge about risks	11
3:1 Lack of trust “essentially more important” than lack of knowledge about risks	3
2:1 Lack of trust “weakly more important” than lack of knowledge about risks	1
1:1 Lack of trust “equally important “lack of knowledge about risks	5
1:2 Lack of knowledge about risks “weakly more important” than lack of trust	0
1:3 Lack of knowledge about risks “essentially more important” than lack of trust	0
1:4 Lack of knowledge about risks “very strongly more important” than lack of trust	0
1:5 Lack of knowledge about risks “absolutely more important” than lack of trust	0
11. "Lack of Trust" and "Wrong Partner Selection" comparison.	
5:1 Lack of trust “absolutely more important” than wrong partner selection	3
4:1 Lack of trust “very strongly more important” than wrong partner selection	4
3:1 Lack of trust “essentially more important” than wrong partner selection	7
2:1 Lack of trust “weakly more important” than wrong partner selection	26

1:1 Lack of trust “equally important “wrong partner selection	2
1:2 Wrong partner selection “weakly more important” than lack of trust	2
1:3 Wrong partner selection “essentially more important” than lack of trust	1
1:4 Wrong partner selection “very strongly more important” than lack of trust	0
1:5 Wrong partner selection “absolutely more important” than lack of trust	0
12. "Lack of Trust" and "Geographic Location" comparison.	
5:1 Lack of trust “absolutely more important” than geographic location	36
4:1 Lack of trust “very strongly more important” than geographic location	5
3:1 Lack of trust “essentially more important” than geographic location	4
2:1 Lack of trust “weakly more important” than geographic location	0
1:1 Lack of trust “equally important “geographic location	0
1:2 Geographic location “weakly more important” than lack of trust	0
1:3 Geographic location “essentially more important” than lack of trust	0
1:4 Geographic location “very strongly more important” than lack of trust	0
1:5 Geographic location “absolutely more important” than lack of trust	0
13. "Inadequate Collaboration Agreement" and "Heterogeneity of Partners" comparison.	
5:1 Inadequate collaboration agreement “more important” than heterogeneity of partners	4
4:1 Inadequate collaboration agreement “very strongly more important” than heterogeneity of partners	3
3:1 Inadequate collaboration agreement “essentially more important” than heterogeneity of partners	6
2:1 Inadequate collaboration agreement “weakly more important” than heterogeneity of partners	28
1:1 Inadequate collaboration agreement “equally important “heterogeneity of partners	1
1:2 Heterogeneity of partners “weakly more important” than inadequate collaboration agreement	2
1:3 Heterogeneity of partners “essentially more important” than inadequate collaboration agreement	0
1:4 Heterogeneity of partners “very strongly more important” than inadequate collaboration agreement	0
1:5 Heterogeneity of partners “absolutely more important” than inadequate collaboration agreement	1
14. "Inadequate Collaboration Agreement" and "Ontology Differences" comparison.	
5:1 Inadequate collaboration agreement “more important” than ontology differences	2
4:1 Inadequate collaboration agreement “very strongly more important” than ontology differences	5
3:1 Inadequate collaboration agreement “essentially more important” than ontology differences	26
2:1 Inadequate collaboration agreement “weakly more important” than ontology differences	8
1:1 Inadequate collaboration agreement “equally important “ontology differences	1
1:2 Ontology differences “weakly more important” than inadequate collaboration agreement	1
1:3 Ontology differences “essentially more important” than inadequate collaboration agreement	0
1:4 Ontology differences “very strongly more important” than inadequate collaboration agreement	1
1:5 Ontology differences “absolutely more important” than inadequate collaboration agreement	1
15. "Inadequate Collaboration Agreement" and "Structure and Design" comparison.	
5:1 Inadequate collaboration agreement “more important” than structure and design	4
4:1 Inadequate collaboration agreement “very strongly more important” than structure and design	2
3:1 Inadequate collaboration agreement “essentially more important” than structure and design	24
2:1 Inadequate collaboration agreement “weakly more important” than structure and design	10
1:1 Inadequate collaboration agreement “equally important “structure and design	1
1:2 Structure and design “weakly more important” than inadequate collaboration agreement	3
1:3 Structure and design “essentially more important” than inadequate collaboration agreement	0
1:4 Structure and design “very strongly more important” than inadequate collaboration agreement	0
1:5 Structure and design “absolutely more important” than inadequate collaboration agreement	1
16. "Inadequate Collaboration Agreement" and "Loss of Communication" comparison.	
5:1 Inadequate collaboration agreement “more important” than loss of communication	2
4:1 Inadequate collaboration agreement “very strongly more important” than loss of communication	3
3:1 Inadequate collaboration agreement “essentially more important” than loss of communication	1
2:1 Inadequate collaboration agreement “weakly more important” than loss of communication	2
1:1 Inadequate collaboration agreement “equally important “loss of communication	3
1:2 Loss of communication “weakly more important” than inadequate collaboration agreement	29
1:3 Loss of communication “essentially more important” than inadequate collaboration agreement	2
1:4 Loss of communication “very strongly more important” than inadequate collaboration agreement	1
1:5 Loss of communication “absolutely more important” than inadequate collaboration agreement	2
17. "Inadequate Collaboration Agreement" and "Culture differences" comparison.	
5:1 Inadequate collaboration agreement “more important” than Culture differences	10
4:1 Inadequate collaboration agreement “very strongly more important” than Culture differences	30
3:1 Inadequate collaboration agreement “essentially more important” than Culture differences	2
2:1 Inadequate collaboration agreement “weakly more important” than Culture differences	3
1:1 Inadequate collaboration agreement “equally important “Culture differences	0
1:2 Culture differences “weakly more important” than inadequate collaboration agreement	0
1:3 Culture differences “essentially more important” than inadequate collaboration agreement	0
1:4 Culture differences “very strongly more important” than inadequate collaboration agreement	0

1:5 Culture differences “absolutely more important” than inadequate collaboration agreement	0
18. "Inadequate Collaboration Agreement" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Inadequate collaboration agreement “more important” than bidding for several VO at the same	24
4:1 Inadequate collaboration agreement “very strongly more important” than bidding for several VO at the same	15
3:1 Inadequate collaboration agreement “essentially more important” than bidding for several VO at the same	4
2:1 Inadequate collaboration agreement “weakly more important” than bidding for several VO at the same	2
1:1 Inadequate collaboration agreement “equally important “bidding for several VO at the same	0
1:2 Bidding for several VO at the same “weakly more important” than inadequate collaboration agreement	0
1:3 Bidding for several VO at the same “essentially more important” than inadequate collaboration agreement	0
1:4 Bidding for several VO at the same “very strongly more important” than inadequate collaboration agreement	0
1:5 Bidding for several VO at the same “absolutely more important” than inadequate collaboration agreement	0
19. "Inadequate Collaboration Agreement" and "Lack of Information Sharing" comparison.	
5:1 Inadequate collaboration agreement “more important” than lack of information sharing	2
4:1 Inadequate collaboration agreement “very strongly more important” than lack of information sharing	2
3:1 Inadequate collaboration agreement “essentially more important” than lack of information sharing	1
2:1 Inadequate collaboration agreement “weakly more important” than lack of information sharing	3
1:1 Inadequate collaboration agreement “equally important “lack of information sharing	4
1:2 Lack of information sharing “weakly more important” than inadequate collaboration agreement	29
1:3 Lack of information sharing “essentially more important” than inadequate collaboration agreement	2
1:4 Lack of information sharing “very strongly more important” than inadequate collaboration agreement	2
1:5 Lack of information sharing “absolutely more important” than inadequate collaboration agreement	0
20. "Inadequate Collaboration Agreement" and "Top Management Commitment" comparison.	
5:1 Inadequate collaboration agreement “more important” than top management commitment	1
4:1 Inadequate collaboration agreement “very strongly more important” than top management commitment	0
3:1 Inadequate collaboration agreement “essentially more important” than top management commitment	2
2:1 Inadequate collaboration agreement “weakly more important” than top management commitment	2
1:1 Inadequate collaboration agreement “equally important “top management commitment	34
1:2 Top management commitment “weakly more important” than inadequate collaboration agreement	1
1:3 Top management commitment “essentially more important” than inadequate collaboration agreement	1
1:4 Top management commitment “very strongly more important” than inadequate collaboration agreement	1
1:5 Top management commitment “absolutely more important” than inadequate collaboration agreement	3
21. "Inadequate Collaboration Agreement" and "Lack of Knowledge about Risks" comparison.	
5:1 Inadequate collaboration agreement “more important” than lack of knowledge about risks	9
4:1 Inadequate collaboration agreement “very strongly more important” than lack of knowledge about risks	27
3:1 Inadequate collaboration agreement “essentially more important” than lack of knowledge about risks	3
2:1 Inadequate collaboration agreement “weakly more important” than lack of knowledge about risks	3
1:1 Inadequate collaboration agreement “equally important “lack of knowledge about risks	2
1:2 Lack of knowledge about risks “weakly more important” than inadequate collaboration agreement	1
1:3 Lack of knowledge about risks “essentially more important” than inadequate collaboration agreement	0
1:4 Lack of knowledge about risks “very strongly more important” than inadequate collaboration agreement	0
1:5 Lack of knowledge about risks “absolutely more important” than inadequate collaboration agreement	0
22. "Inadequate Collaboration Agreement" and "Wrong Partner Selection" comparison.	
5:1 Inadequate collaboration agreement “more important” than wrong partner selection	1
4:1 Inadequate collaboration agreement “very strongly more important” than wrong partner selection	2
3:1 Inadequate collaboration agreement “essentially more important” than wrong partner selection	2
2:1 Inadequate collaboration agreement “weakly more important” than wrong partner selection	3
1:1 Inadequate collaboration agreement “equally important “wrong partner selection	2
1:2 Wrong partner selection “weakly more important” than inadequate collaboration agreement	4
1:3 Wrong partner selection “essentially more important” than inadequate collaboration agreement	29
1:4 Wrong partner selection “very strongly more important” than inadequate collaboration agreement	1
1:5 Wrong partner selection “absolutely more important” than inadequate collaboration agreement	1
23. "Inadequate Collaboration Agreement" and "Geographic Location" comparison.	
5:1 Inadequate collaboration agreement “more important” than geographic location	34
4:1 Inadequate collaboration agreement “very strongly more important” than geographic location	2
3:1 Inadequate collaboration agreement “essentially more important” than geographic location	2
2:1 Inadequate collaboration agreement “weakly more important” than geographic location	5

1:1 Inadequate collaboration agreement “equally important “geographic location	2
1:2 Geographic location “weakly more important” than inadequate collaboration agreement	0
1:3 Geographic location “essentially more important” than inadequate collaboration agreement	0
1:4 Geographic location “very strongly more important” than inadequate collaboration agreement	0
1:5 Geographic location “absolutely more important” than inadequate collaboration agreement	0
24. "Heterogeneity of Partners" and "Ontology Differences" comparison.	
5:1 Heterogeneity of partners “more important” than ontology differences	1
4:1 Heterogeneity of partners “very strongly more important” than ontology differences	3
3:1 Heterogeneity of partners “essentially more important” than ontology differences	8
2:1 Heterogeneity of partners “weakly more important” than ontology differences	24
1:1 Heterogeneity of partners “equally important “ontology differences	3
1:2 Ontology differences “weakly more important” than heterogeneity of partners	3
1:3 Ontology differences “essentially more important” than heterogeneity of partners	2
1:4 Ontology differences “very strongly more important” than heterogeneity of partners	1
1:5 Ontology differences “absolutely more important” than heterogeneity of partners	0
25. "Heterogeneity of Partners" and "Structure and Design" comparison.	
5:1 Heterogeneity of partners “more important” than structure and design	1
4:1 Heterogeneity of partners “very strongly more important” than structure and design	3
3:1 Heterogeneity of partners “essentially more important” than structure and design	6
2:1 Heterogeneity of partners “weakly more important” than structure and design	23
1:1 Heterogeneity of partners “equally important “structure and design	8
1:2 Structure and design “weakly more important” than heterogeneity of partners	2
1:3 Structure and design “essentially more important” than heterogeneity of partners	1
1:4 Structure and design “very strongly more important” than heterogeneity of partners	0
1:5 Structure and design “absolutely more important” than heterogeneity of partners	1
26. "Heterogeneity of Partners" and "Loss of Communication" comparison.	
5:1 Heterogeneity of partners “more important” than loss of communication	0
4:1 Heterogeneity of partners “very strongly more important” than loss of communication	0
3:1 Heterogeneity of partners “essentially more important” than loss of communication	0
2:1 Heterogeneity of partners “weakly more important” than loss of communication	0
1:1 Heterogeneity of partners “equally important “loss of communication	0
1:2 Loss of communication “weakly more important” than heterogeneity of partners	9
1:3 Loss of communication “essentially more important” than heterogeneity of partners	26
1:4 Loss of communication “very strongly more important” than heterogeneity of partners	5
1:5 Loss of communication “absolutely more important” than heterogeneity of partners	5
27. "Heterogeneity of Partners" and "Culture differences" comparison.	
5:1 Heterogeneity of partners “more important” than Culture differences	4
4:1 Heterogeneity of partners “very strongly more important” than Culture differences	24
3:1 Heterogeneity of partners “essentially more important” than Culture differences	7
2:1 Heterogeneity of partners “weakly more important” than Culture differences	6
1:1 Heterogeneity of partners “equally important “Culture differences	1
1:2 Culture differences “weakly more important” than heterogeneity of partners	1
1:3 Culture differences “essentially more important” than heterogeneity of partners	1
1:4 Culture differences “very strongly more important” than heterogeneity of partners	0
1:5 Culture differences “absolutely more important” than heterogeneity of partners	1
28. "Heterogeneity of Partners" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Heterogeneity of partners “more important” than bidding for several VO at the same	25
4:1 Heterogeneity of partners “very strongly more important” than bidding for several VO at the same	7
3:1 Heterogeneity of partners “essentially more important” than bidding for several VO at the same	8
2:1 Heterogeneity of partners “weakly more important” than bidding for several VO at the same	2
1:1 Heterogeneity of partners “equally important “bidding for several VO at the same	1
1:2 Bidding for several VO at the same “weakly more important” than heterogeneity of partners	1
1:3 Bidding for several VO at the same “essentially more important” than heterogeneity of partners	0
1:4 Bidding for several VO at the same “very strongly more important” than heterogeneity of partners	0
1:5 Bidding for several VO at the same “absolutely more important” heterogeneity of partners	1
29. "Heterogeneity of Partners" and "Lack of Information Sharing" comparison.	
5:1 Heterogeneity of partners “more important” than lack of information sharing	1
4:1 Heterogeneity of partners “very strongly more important” than lack of information sharing	0
3:1 Heterogeneity of partners “essentially more important” than lack of information sharing	0
2:1 Heterogeneity of partners “weakly more important” than lack of information sharing	0
1:1 Heterogeneity of partners “equally important “ information sharing	1
1:2 Lack of information sharing “weakly more important” than heterogeneity of partners	3
1:3 Lack of information sharing “essentially more important” than heterogeneity of partners	28
1:4 Lack of information sharing “very strongly more important” than heterogeneity of partners	7

1:5 Lack of information sharing “absolutely more important” than heterogeneity of partners	5
30. "Heterogeneity of Partners" and "Lack of Top Management Commitment" comparison.	
5:1 Heterogeneity of partners “more important” than lack of top management commitment	1
4:1 Heterogeneity of partners “very strongly more important” than lack of top management commitment	0
3:1 Heterogeneity of partners “essentially more important” than lack of top management commitment	1
2:1 Heterogeneity of partners “weakly more important” than lack of top management commitment	0
1:1 Heterogeneity of partners “equally important “lack of top management commitment	3
1:2 Lack of Top management commitment “weakly more important” than heterogeneity of partners	31
1:3 Lack of Top management commitment “essentially more important” than heterogeneity of partners	3
1:4 Lack of Top management commitment “very strongly more important” than heterogeneity of partners	3
1:5 Lack of Top management commitment “absolutely more important” than heterogeneity of partners	3
31. "Heterogeneity of Partners" and "Lack of Knowledge about Risks" comparison.	
5:1 Heterogeneity of partners “more important” than lack of knowledge about risks	1
4:1 Heterogeneity of partners “very strongly more important” than lack of knowledge about risks	1
3:1 Heterogeneity of partners “essentially more important” than lack of knowledge about risks	23
2:1 Heterogeneity of partners “weakly more important” than lack of knowledge about risks	12
1:1 Heterogeneity of partners “equally important “lack of knowledge about risks	3
1:2 Lack of knowledge about risks “weakly more important” than heterogeneity of partners	1
1:3 Lack of knowledge about risks “essentially more important” than heterogeneity of partners	1
1:4 Lack of knowledge about risks “very strongly more important” than heterogeneity of partners	1
1:5 Lack of knowledge about risks “absolutely more important” than heterogeneity of partners	2
32. "Heterogeneity of partners" and "Wrong Partner Selection" comparison.	
5:1 Heterogeneity of partners “more important” than wrong partner selection	0
4:1 Heterogeneity of partners “very strongly more important” than wrong partner selection	0
3:1 Heterogeneity of partners “essentially more important” than wrong partner selection	0
2:1 Heterogeneity of partners “weakly more important” than wrong partner selection	0
1:1 Heterogeneity of partners “equally important “wrong partner selection	0
1:2 Wrong partner selection “weakly more important” than heterogeneity of partners	1
1:3 Wrong partner selection “essentially more important” than heterogeneity of partners	3
1:4 Wrong partner selection “very strongly more important” than heterogeneity of partners	25
1:5 Wrong partner selection “absolutely more important” than heterogeneity of partners	16
33. "Heterogeneity of Partners" and "Geographic Location" comparison.	
5:1 Heterogeneity of partners “more important” than geographic location	26
4:1 Heterogeneity of partners “very strongly more important” than geographic location	7
3:1 Heterogeneity of partners “essentially more important” than geographic location	8
2:1 Heterogeneity of partners “weakly more important” than geographic location	2
1:1 Heterogeneity of partners “equally important “geographic location	1
1:2 Geographic location “weakly more important” than heterogeneity of partners	0
1:3 Geographic location “essentially more important” than heterogeneity of partners	0
1:4 Geographic location “very strongly more important” than heterogeneity of partners	0
1:5 Geographic location “absolutely more important” than heterogeneity of partners	1
34. "Ontology Differences" and "Structure and Design" comparison.	
5:1 Ontology differences “more important” than structure and design	2
4:1 Ontology differences “very strongly more important” than structure and design	1
3:1 Ontology differences “essentially more important” than structure and design	3
2:1 Ontology differences “weakly more important” than structure and design	27
1:1 Ontology differences “equally important “structure and design	5
1:2 Structure and design “weakly more important” than ontology differences	4
1:3 Structure and design “essentially more important” than ontology differences	1
1:4 Structure and design “very strongly more important” than ontology differences	1
1:5 Structure and design “absolutely more important” than ontology differences	1
35. "Ontology Differences" and "Loss of Communication" comparison.	
5:1 Ontology differences “more important” than loss of communication	1
4:1 Ontology differences “very strongly more important” than loss of communication	2
3:1 Ontology differences “essentially more important” than loss of communication	0
2:1 Ontology differences “weakly more important” than loss of communication	0
1:1 Ontology differences “equally important “loss of communication	0
1:2 Loss of communication “weakly more important” than ontology differences	2
1:3 Loss of communication “essentially more important” than ontology differences	3
1:4 Loss of communication “very strongly more important” than ontology differences	30
1:5 Loss of communication “absolutely more important” than ontology differences	7
36. "Ontology Differences" and "Culture differences" comparison.	
5:1 Ontology differences “more important” than Culture differences	5
4:1 Ontology differences “very strongly more important” than Culture differences	29

3:1 Ontology differences “essentially more important” than Culture differences	2
2:1 Ontology differences “weakly more important” than Culture differences	1
1:1 Ontology differences “equally important “Culture differences	2
1:2 Culture differences “weakly more important” than ontology differences	2
1:3 Culture differences “essentially more important” than ontology differences	2
1:4 Culture differences “very strongly more important” than ontology differences	0
1:5 Culture differences “absolutely more important” than ontology differences	2
37. "Ontology Differences" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Ontology differences “more important” than bidding for several VO at the same	31
4:1 Ontology differences “very strongly more important” than bidding for several VO at the same	2
3:1 Ontology differences “essentially more important” than bidding for several VO at the same	2
2:1 Ontology differences “weakly more important” than bidding for several VO at the same	1
1:1 Ontology differences “equally important “bidding for several VO at the same	3
1:2 Bidding for several VO at the same “weakly more important” than ontology differences	1
1:3 Bidding for several VO at the same “essentially more important” than ontology differences	1
1:4 Bidding for several VO at the same “very strongly more important” than ontology differences	1
1:5 Bidding for several VO at the same “absolutely more important” ontology differences	3
38. "Ontology Differences" and "Lack of Information Sharing" comparison.	
5:1 Ontology differences “more important” than lack of information sharing	1
4:1 Ontology differences “very strongly more important” than lack of information sharing	1
3:1 Ontology differences “essentially more important” than lack of information sharing	2
2:1 Ontology differences “weakly more important” than lack of information sharing	1
1:1 Ontology differences “equally important “lack of information sharing	3
1:2 Lack of information sharing “weakly more important” than ontology differences	2
1:3 Lack of information sharing “essentially more important” than ontology differences	1
1:4 Lack of information sharing “very strongly more important” than ontology differences	27
1:5 Lack of information sharing “absolutely more important” than ontology differences	7
39. "Ontology differences" and "Lack of Top Management Commitment" comparison.	
5:1 Ontology differences “more important” than lack of top management commitment	1
4:1 Ontology differences “very strongly more important” than lack of top management commitment	2
3:1 Ontology differences “essentially more important” than lack of top management commitment	2
2:1 Ontology differences “weakly more important” than lack of top management commitment	1
1:1 Ontology differences “equally important “lack of top management commitment	2
1:2 Lack of top management commitment “weakly more important” than ontology differences	2
1:3 Lack of top management commitment “essentially more important” than ontology differences	28
1:4 Lack of top management commitment “very strongly more important” than ontology differences	3
1:5 Lack of top management commitment “absolutely more important” than ontology differences	4
40. "Ontology Differences" and "Lack of Knowledge about Risks" comparison.	
5:1 Ontology differences “more important” than lack of knowledge about risks	3
4:1 Ontology differences “very strongly more important” than lack of knowledge about risks	4
3:1 Ontology differences “essentially more important” than lack of knowledge about risks	30
2:1 Ontology differences “weakly more important” than lack of knowledge about risks	4
1:1 Ontology differences “equally important “lack of knowledge about risks	3
1:2 Lack of knowledge about risks “weakly more important” than ontology differences	0
1:3 Lack of knowledge about risks “essentially more important” than ontology differences	0
1:4 Lack of knowledge about risks “very strongly more important” than ontology differences	0
1:5 Lack of knowledge about risks “absolutely more important” than ontology differences	1
41. "Ontology Differences" and "Wrong Partner Selection" comparison.	
5:1 Ontology differences “more important” than wrong partner selection	1
4:1 Ontology differences “very strongly more important” than wrong partner selection	0
3:1 Ontology differences “essentially more important” than wrong partner selection	0
2:1 Ontology differences “weakly more important” than wrong partner selection	0
1:1 Ontology differences “equally important “wrong partner selection	2
1:2 Wrong partner selection “weakly more important” than ontology differences	5
1:3 Wrong partner selection “essentially more important” than ontology differences	2
1:4 Wrong partner selection “very strongly more important” than ontology differences	30
1:5 Wrong partner selection “absolutely more important” than ontology differences	5
42. "Ontology Differences" and "Geographic Location" comparison.	
5:1 Ontology differences “more important” than geographic location	31
4:1 Ontology differences “very strongly more important” than geographic location	9
3:1 Ontology differences “essentially more important” than geographic location	2
2:1 Ontology differences “weakly more important” than geographic location	0
1:1 Ontology differences “equally important “geographic location	1
1:2 Geographic location “weakly more important” than Ontology differences	0

1:3 Geographic location “essentially more important” than Ontology differences	0
1:4 Geographic location “very strongly more important” than Ontology differences	0
1:5 Geographic location “absolutely more important” than Ontology differences	2
43. "Structure and Design" and "Loss of Communication" comparison.	
5:1 Structure and design “more important” than loss of communication	0
4:1 Structure and design “very strongly more important” than loss of communication	0
3:1 Structure and design “essentially more important” than loss of communication	0
2:1 Structure and design “weakly more important” than loss of communication	0
1:1 Structure and design “equally important “loss of communication	2
1:2 Loss of communication “weakly more important” than structure and design	4
1:3 Loss of communication “essentially more important” than structure and design	1
1:4 Loss of communication “very strongly more important” than structure and design	30
1:5 Loss of communication “absolutely more important” than structure and design	8
44. "Structure and Design" and "Culture differences" comparison.	
5:1 Structure and design “more important” than Culture differences	3
4:1 Structure and design “very strongly more important” than Culture differences	4
3:1 Structure and design “essentially more important” than Culture differences	23
2:1 Structure and design “weakly more important” than Culture differences	12
1:1 Structure and design “equally important “Culture differences	1
1:2 Culture differences “weakly more important” than structure and design	0
1:3 Culture differences “essentially more important” than structure and design	0
1:4 Culture differences “very strongly more important” than structure and design	0
1:5 Culture differences “absolutely more important” than structure and design	2
45. "Structure and Design" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Structure and design “more important” than bidding for several VO at the same	5
4:1 Structure and design “very strongly more important” than bidding for several VO at the same	28
3:1 Structure and design “essentially more important” than bidding for several VO at the same	4
2:1 Structure and design “weakly more important” than bidding for several VO at the same	1
1:1 Structure and design “equally important “bidding for several VO at the same	2
1:2 Bidding for several VO at the same “weakly more important” than structure and design	1
1:3 Bidding for several VO at the same “essentially more important” than structure and design	0
1:4 Bidding for several VO at the same “very strongly more important” than structure and design	1
1:5 Bidding for several VO at the same “absolutely more important” structure and design	3
46. "Structure and Design" and "Information Sharing" comparison.	
5:1 Structure and design “more important” than information sharing	1
4:1 Structure and design “very strongly more important” than information sharing	0
3:1 Structure and design “essentially more important” than information sharing	0
2:1 Structure and design “weakly more important” than information sharing	0
1:1 Structure and design “equally important “information sharing	3
1:2 Lack of information sharing“weakly more important” than structure and design	2
1:3 Lack of information sharing“essentially more important” than structure and design s	3
1:4 Lack of information sharing“very strongly more important” than structure and design	25
1:5 Lack of information sharing“absolutely more important” than structure and design	11
47. "Structure and Design" and "Top Management Commitment" comparison.	
5:1 Structure and design “more important” than top management commitment	1
4:1 Structure and design “very strongly more important” than top management commitment	1
3:1 Structure and design “essentially more important” than top management commitment	2
2:1 Structure and design “weakly more important” than top management commitment	4
1:1 Structure and design “equally important “top management commitment	1
1:2 Top management commitment “weakly more important” than structure and design	2
1:3 Top management commitment “essentially more important” than structure and design	24
1:4 Top management commitment “very strongly more important” than structure and design	9
1:5 Top management commitment “absolutely more important” than structure and design	1
48. "Structure and Design" and "Knowledge about Risks" comparison.	
5:1 Structure and design “more important” than knowledge about risks	1
4:1 Structure and design “very strongly more important” than knowledge about risks	2
3:1 Structure and design “essentially more important” than knowledge about risks	2
2:1 Structure and design “weakly more important” than knowledge about risks	23
1:1 Structure and design “equally important “knowledge about risks	15
1:2 Knowledge about risks “weakly more important” than structure and design	0
1:3 Knowledge about risks “essentially more important” than structure and design	0
1:4 Knowledge about risks “very strongly more important” than structure and design	1
1:5 Knowledge about risks “absolutely more important” than structure and design	1
49. "Structure and Design" and "Wrong Partner Selection" comparison.	

5:1 Structure and design “more important” than wrong partner selection	0
4:1 Structure and design “very strongly more important” than wrong partner selection	0
3:1 Structure and design “essentially more important” than wrong partner selection	1
2:1 Structure and design “weakly more important” than wrong partner selection	0
1:1 Structure and design “equally important “wrong partner selection	3
1:2 Wrong partner selection “weakly more important” than structure and design	1
1:3 Wrong partner selection “essentially more important” than structure and design	5
1:4 Wrong partner selection “very strongly more important” than structure and design	10
1:5 Wrong partner selection “absolutely more important” than structure and design	25
50. "Structure and Design" and "Geographic Location" comparison.	
5:1 Structure and design “more important” than geographic location	13
4:1 Structure and design “very strongly more important” than geographic location	26
3:1 Structure and design “essentially more important” than geographic location	4
2:1 Structure and design “weakly more important” than geographic location	1
1:1 Structure and design “equally important “geographic location	1
1:2 Geographic location “weakly more important” than Structure and design	0
1:3 Geographic location “essentially more important” than Structure and design	0
1:4 Geographic location “very strongly more important” than Structure and design	0
1:5 Geographic location “absolutely more important” than Structure and design	0
51. "Loss of Communication" and "Culture differences" comparison.	
5:1 Loss of communication “more important” than Culture differences	37
4:1 Loss of communication “very strongly more important” than Culture differences	3
3:1 Loss of communication “essentially more important” than Culture differences	5
2:1 Loss of communication “weakly more important” than Culture differences	0
1:1 Loss of communication “equally important “Culture differences	0
1:2 Culture differences “weakly more important” than loss of communication	0
1:3 Culture differences “essentially more important” than loss of communication	0
1:4 Culture differences “very strongly more important” than loss of communication	0
1:5 Culture differences “absolutely more important” than loss of communication	0
52. "Loss of Communication" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Loss of communication “more important” than bidding for several VO at the same	35
4:1 Loss of communication “very strongly more important” than bidding for several VO at the same	4
3:1 Loss of communication “essentially more important” than bidding for several VO at the same	2
2:1 Loss of communication “weakly more important” than bidding for several VO at the same	3
1:1 Loss of communication “equally important “bidding for several VO at the same	1
1:2 Bidding for several VO at the same “weakly more important” than loss of communication	0
1:3 Bidding for several VO at the same “essentially more important” than loss of communication	0
1:4 Bidding for several VO at the same “very strongly more important” than loss of communication	0
1:5 Bidding for several VO at the same “absolutely more important” loss of communication	0
53. "Loss of Communication" and "Lack of Information Sharing" comparison.	
5:1 Loss of communication “more important” than lack of information sharing	5
4:1 Loss of communication “very strongly more important” than lack of information sharing	2
3:1 Loss of communication “essentially more important” than lack of information sharing	1
2:1 Loss of communication “weakly more important” than lack of information sharing	5
1:1 Loss of communication “equally important “lack of information sharing	27
1:2 Lack of information sharing “weakly more important” than loss of communication	1
1:3 Lack of information sharing “essentially more important” than loss of communication	2
1:4 Lack of information sharing “very strongly more important” than loss of communication	1
1:5 Lack of information sharing “absolutely more important” than loss of communication	1
54. "Loss of Communication" and "Lack of Top Management Commitment" comparison.	
5:1 Loss of communication “more important” than lack of top management commitment	2
4:1 Loss of communication “very strongly more important” than lack of top management commitment	3
3:1 Loss of communication “essentially more important” than lack of top management commitment	10
2:1 Loss of communication “weakly more important” than lack of top management commitment	23
1:1 Loss of communication “equally important “lack of top management commitment	4
1:2 Lack of top management commitment “weakly more important” than loss of communication	0
1:3 Lack of top management commitment “essentially more important” than loss of communication	1
1:4 Lack of top management commitment “very strongly more important” than loss of communication	1
1:5 Lack of top management commitment “absolutely more important” than loss of communication	1
55. "Loss of Communication" and "Lack of Knowledge about Risks" comparison.	
5:1 Loss of communication “more important” than lack of knowledge about risks	27
4:1 Loss of communication “very strongly more important” than lack of knowledge about risks	8
3:1 Loss of communication “essentially more important” than lack of knowledge about risks	3
2:1 Loss of communication “weakly more important” than lack of knowledge about risks	4

1:1 Loss of communication “equally important “lack of knowledge about risks	1
1:2 Lack of knowledge about risks “weakly more important” than loss of communication	1
1:3 Lack of knowledge about risks “essentially more important” than loss of communication	1
1:4 Lack of knowledge about risks “very strongly more important” than loss of communication	0
1:5 Lack of knowledge about risks “absolutely more important” than loss of communication	0
56. "Loss of Communication" and "Wrong Partner Selection" comparison	
5:1 Loss of communication “more important” than wrong partner selection	2
4:1 Loss of communication “very strongly more important” than wrong partner selection	3
3:1 Loss of communication “essentially more important” than wrong partner selection	3
2:1 Loss of communication “weakly more important” than wrong partner selection	2
1:1 Loss of communication “equally important “wrong partner selection	2
1:2 Wrong partner selection “weakly more important” than loss of communication	28
1:3 Wrong partner selection “essentially more important” than loss of communication	2
1:4 Wrong partner selection “very strongly more important” than loss of communication	1
1:5 Wrong partner selection “absolutely more important” than loss of communication	2
57. "Loss of Communication" and "Geographic Location" comparison.	
5:1 Loss of communication “more important” than geographic location	36
4:1 Loss of communication “very strongly more important” than geographic location	3
3:1 Loss of communication “essentially more important” than geographic location	3
2:1 Loss of communication “weakly more important” than geographic location	2
1:1 Loss of communication “equally important “geographic location	1
1:2 Geographic location “weakly more important” than loss of communication	0
1:3 Geographic location “essentially more important” than loss of communication	0
1:4 Geographic location “very strongly more important” than loss of communication	0
1:5 Geographic location “absolutely more important” than loss of communication	0
58. "Culture differences" and "Bidding for Several VO at the Same Time" comparison.	
5:1 Culture differences “more important” than bidding for several VO at the same	2
4:1 Culture differences “very strongly more important” than bidding for several VO at the same	3
3:1 Culture differences “essentially more important” than bidding for several VO at the same	10
2:1 Culture differences “weakly more important” than bidding for several VO at the same	24
1:1 Culture differences “equally important “bidding for several VO at the same	2
1:2 Bidding for several VO at the same “weakly more important” than Culture differences	1
1:3 Bidding for several VO at the same “essentially more important” than Culture differences	1
1:4 Bidding for several VO at the same “very strongly more important” than Culture differences	0
1:5 Bidding for several VO at the same “absolutely more important” Culture differences	2
59. "Culture differences" and "Lack of Information Sharing" comparison.	
5:1 Culture differences “more important” than lack of information sharing	0
4:1 Culture differences “very strongly more important” than lack of information sharing	0
3:1 Culture differences “essentially more important” than lack of information sharing	0
2:1 Culture differences “weakly more important” than lack of information sharing	0
1:1 Culture differences “equally important “lack of information sharing	1
1:2 Lack of information sharing “weakly more important” than Culture differences	1
1:3 Lack of information sharing “essentially more important” than Culture differences	2
1:4 Lack of information sharing “very strongly more important” than Culture differences	3
1:5 Lack of information sharing “absolutely more important” than Culture differences	38
60. "Culture differences" and "Lack Top Management Commitment" comparison.	
5:1 Culture differences “more important” than lack of top management commitment	0
4:1 Culture differences “very strongly more important” than lack of top management commitment	0
3:1 Culture differences “essentially more important” than lack of top management commitment	0
2:1 Culture differences “weakly more important” than lack of top management commitment	1
1:1 Culture differences “equally important “lack of top management commitment	1
1:2 Lack of top management commitment “weakly more important” than Culture differences	1
1:3 Lack of top management commitment “essentially more important” than Culture differences	10
1:4 Lack of top management commitment “very strongly more important” than Culture differences	25
1:5 Lack of top management commitment “absolutely more important” than Culture differences	7
61. "Culture differences" and "Lack of Knowledge about Risks" comparison.	
5:1 Culture differences “more important” than lack of knowledge about risks	1
4:1 Culture differences “very strongly more important” than lack of knowledge about risks	0
3:1 Culture differences “essentially more important” than lack of knowledge about risks	1
2:1 Culture differences “weakly more important” than lack of knowledge about risks	4
1:1 Culture differences “equally important “lack of knowledge about risks	5
1:2 Lack of knowledge about risks “weakly more important” than Culture differences	27
1:3 Lack of knowledge about risks “essentially more important” than Culture differences	5
1:4 Lack of knowledge about risks “very strongly more important” than Culture differences	1

1:5 Lack of knowledge about risks “absolutely more important” than Culture differences	1
62. "Culture differences" and "Wrong Partner Selection" comparison.	
5:1 Culture differences “more important” than wrong partner selection	0
4:1 Culture differences “very strongly more important” than wrong partner selection	0
3:1 Culture differences “essentially more important” than wrong partner selection	0
2:1 Culture differences “weakly more important” than wrong partner selection	0
1:1 Culture differences “equally important “wrong partner selection	0
1:2 Wrong partner selection “weakly more important” than Culture differences	3
1:3 Wrong partner selection “essentially more important” than Culture differences	3
1:4 Wrong partner selection “very strongly more important” than Culture differences	9
1:5 Wrong partner selection “absolutely more important” than Culture differences	30
63. "Culture differences" and "Geographic Location" comparison.	
5:1 Culture differences “more important” than geographic location	1
4:1 Culture differences “very strongly more important” than geographic location	1
3:1 Culture differences “essentially more important” than geographic location	6
2:1 Culture differences “weakly more important” than geographic location	23
1:1 Culture differences “equally important “geographic location	5
1:2 Geographic location “weakly more important” than Culture differences	6
1:3 Geographic location “essentially more important” than Culture differences	1
1:4 Geographic location “very strongly more important” than Culture differences	1
1:5 Geographic location “absolutely more important” than Culture differences	1
64. "Bidding for Several VO at the Same Time" and "Lack of Information Sharing" comparison.	
5:1 Bidding for several VO at the same time “more important” than lack of information sharing	1
4:1 Bidding for several VO at the same time “very strongly more important” than lack of information sharing	0
3:1 Bidding for several VO at the same time “essentially more important” than lack of information sharing	0
2:1 Bidding for several VO at the same time “weakly more important” than lack of information sharing	0
1:1 Bidding for several VO at the same time “equally important “lack of information sharing	2
1:2 Lack of information sharing “weakly more important” than bidding for several VO at the same time	1
1:3 Lack of information sharing “essentially more important” than bidding for several VO at the same time	2
1:4 Lack of information sharing “very strongly more important” than bidding for several VO at the same time	10
1:5 Lack of information sharing “absolutely more important” than bidding for several VO at the same time	29
65. "Bidding for Several VO at the Same Time" and "Lack of Top Management Commitment" comparison.	
5:1 Bidding for several VO at the same time “more important” than lack of top management commitment	1
4:1 Bidding for several VO at the same time “very strongly more important” than lack of top management commitment	2
3:1 Bidding for several VO at the same time “essentially more important” than lack of top management commitment	0
2:1 Bidding for several VO at the same time “weakly more important” than lack of top management commitment	0
1:1 Bidding for several VO at the same time “equally important “lack of top management commitment	3
1:2 Lack of top management commitment “weakly more important” than bidding for several VO at the same time	5
1:3 Lack of top management commitment “essentially more important” than bidding for several VO at the same time	4
1:4 Lack of top management commitment “very strongly more important” than bidding for several VO at the same time	28
1:5 Lack of top management commitment “absolutely more important” than bidding for several VO at the same time	2
66. "Bidding for Several VO at the Same Time" and "Lack of Knowledge about Risks" comparison.	
5:1 Bidding for several VO at the same time “more important” than lack of knowledge about risks	2
4:1 Bidding for several VO at the same time “very strongly more important” than lack of knowledge about risks	0
3:1 Bidding for several VO at the same time “essentially more important” than lack of knowledge about risks	3
2:1 Bidding for several VO at the same time “weakly more important” than lack of knowledge about risks	1
1:1 Bidding for several VO at the same time “equally important “lack of knowledge about risks	5
1:2 Lack of knowledge about risks “weakly more important” than bidding for several VO at the same time	7
1:3 Lack of knowledge about risks “essentially more important” than bidding for several VO at the same time	25
1:4 Lack of knowledge about risks “very strongly more important” than bidding for several VO at the same time	2
1:5 Lack of knowledge about risks “absolutely more important” than bidding for several VO at the same	0

time	
67. "Bidding for Several VO at the Same Time" and "Wrong Partner Selection" comparison.	
5:1 Bidding for several VO at the same time “more important” than wrong partner selection	0
4:1 Bidding for several VO at the same time “very strongly more important” than wrong partner selection	0
3:1 Bidding for several VO at the same time “essentially more important” than wrong partner selection	0
2:1 Bidding for several VO at the same time “weakly more important” than wrong partner selection	0
1:1 Bidding for several VO at the same time “equally important “wrong partner selection	1
1:2 Wrong partner selection “weakly more important” than bidding for several VO at the same time	3
1:3 Wrong partner selection “essentially more important” than bidding for several VO at the same time	5
1:4 Wrong partner selection “very strongly more important” than bidding for several VO at the same time	3
1:5 Wrong partner selection “absolutely more important” than bidding for several VO at the same time	33
68. "Bidding for Several VO at the Same Time" and "Geographic Location" comparison.	
5:1 Bidding for several VO at the same time “more important” than geographic location	0
4:1 Bidding for several VO at the same time “very strongly more important” than geographic location	2
3:1 Bidding for several VO at the same time “essentially more important” than geographic location	1
2:1 Bidding for several VO at the same time “weakly more important” than geographic location	4
1:1 Bidding for several VO at the same time “equally important “geographic location	26
1:2 Geographic location “weakly more important” than bidding for several VO at the same time	1
1:3 Geographic location “essentially more important” than bidding for several VO at the same time	6
1:4 Geographic location “very strongly more important” than bidding for several VO at the same time	2
1:5 Geographic location “absolutely more important” than bidding for several VO at the same time	3
69. "Lack of Information sharing" and "Lack of Top Management Commitment" comparison.	
5:1 Lack of information sharing “more important” than lack of top management commitment	2
4:1 Lack of information sharing “very strongly more important” than lack of top management commitment	1
3:1 Lack of information sharing “essentially more important” than lack of top management commitment	2
2:1 Lack of information sharing “weakly more important” than lack of top management commitment	27
1:1 Lack of information sharing “equally important “lack of top management commitment	6
1:2 Lack of top management commitment “weakly more important” than lack of information sharing	3
1:3 Lack of top management commitment “essentially more important” than lack of information sharing	2
1:4 Lack of top management commitment “very strongly more important” than lack of information sharing	0
1:5 Lack of top management commitment “absolutely more important” than lack of information sharing	2
70. "Lack of Information Sharing" and "Lack of Knowledge about Risks" comparison.	
5:1 Lack of information sharing “more important” than lack of knowledge about risks	26
4:1 Lack of information sharing “very strongly more important” than lack of knowledge about risks	7
3:1 Lack of information sharing “essentially more important” than lack of knowledge about risks	8
2:1 Lack of information sharing “weakly more important” than lack of knowledge about risks	2
1:1 Lack of information sharing “equally important “lack of knowledge about risks	2
1:2 Lack of knowledge about risks “weakly more important” than lack of information sharing	0
1:3 Lack of knowledge about risks “essentially more important” than lack of information sharing	0
1:4 Lack of knowledge about risks “very strongly more important” than lack of information sharing	0
1:5 Lack of Knowledge about risks “absolutely more important” than lack of information sharing	0
71. "Lack of Information Sharing" and "Wrong Partner Selection" comparison.	
5:1 Lack of information sharing “more important” than wrong partner selection	2
4:1 Lack of information sharing “very strongly more important” than wrong partner selection	3
3:1 Lack of information sharing “essentially more important” than wrong partner selection	2
2:1 Lack of information sharing “weakly more important” than wrong partner selection	1
1:1 Lack of information sharing “equally important “wrong partner selection	9
1:2 Wrong partner selection “weakly more important” than lack of information sharing	23
1:3 Wrong partner selection “essentially more important” than lack of information sharing	2
1:4 Wrong partner selection “very strongly more important” than lack of information sharing	1
1:5 Wrong partner selection “absolutely more important” than lack of information sharing	2
72. "Lack of Information Sharing" and "Geographic Location" comparison.	
5:1 Lack of information sharing “more important” than geographic location	35
4:1 Lack of information sharing “very strongly more important” than geographic location	4
3:1 Lack of information sharing “essentially more important” than geographic location	5
2:1 Lack of information sharing “weakly more important” than geographic location	1
1:1 Lack of information sharing “equally important “geographic location	0
1:2 Geographic location “weakly more important” than lack of information sharing	0
1:3 Geographic location “essentially more important” than lack of information sharing	0
1:4 Geographic location “very strongly more important” than lack of information sharing	0
1:5 Geographic location “absolutely more important” than lack of information sharing	0
73. "Lack of Top Management Commitment" and "Lack of Knowledge about Risks" comparison.	
5:1 Lack of top management commitment “more important” than lack of knowledge about risks	10
4:1 Lack of top management commitment “very strongly more important” than lack of knowledge about	26

risks	
3:1 Lack of top management commitment “essentially more important” than lack of knowledge about risks	4
2:1 Lack of top management commitment “weakly more important” than lack of knowledge about risks	3
1:1 Lack of top management commitment “equally important “lack of knowledge about risks	1
1:2 Lack of knowledge about risks “weakly more important” than lack of top management commitment	0
1:3 Lack of knowledge about risks “essentially more important” than lack of top management commitment	0
1:4 Lack of knowledge about risks “very strongly more important” than lack of top management commitment	0
1:5 Lack of knowledge about risks “absolutely more important” than lack of top management commitment	1
74. "Lack of Top Management Commitment" and "Wrong Partner Selection" comparison.	
5:1 Lack of top management commitment “more important” than wrong partner selection	1
4:1 Lack of top management commitment “very strongly more important” than wrong partner selection	0
3:1 Lack of top management commitment “essentially more important” than wrong partner selection	0
2:1 Lack of top management commitment “weakly more important” than wrong partner selection	0
1:1 Lack of top management commitment “equally important “wrong partner selection	2
1:2 Wrong partner selection “weakly more important” than lack of top management commitment	6
1:3 Wrong partner selection “essentially more important” than lack of top management commitment	24
1:4 Wrong partner selection “very strongly more important” than lack of top management commitment	8
1:5 Wrong partner selection “absolutely more important” than lack of top management commitment	4
75. "Lack of Top Management Commitment" and "Geographic Location" comparison.	
5:1 Lack of top management commitment “more important” than geographic location	38
4:1 Lack of top management commitment “very strongly more important” than geographic location	1
3:1 Lack of top management commitment “essentially more important” than geographic location	2
2:1 Lack of top management commitment “weakly more important” than geographic location	4
1:1 Lack of top management commitment “equally important “geographic location	0
1:2 Geographic location “weakly more important” than lack of top management commitment	0
1:3 Geographic location “essentially more important” than lack of top management commitment	0
1:4 Geographic location “very strongly more important” than lack of top management commitment	0
1:5 Geographic location “absolutely more important” than lack of top management commitment	0
76. "Lack of Knowledge about Risks" and "Wrong Partner Selection" comparison.	
5:1 Lack of knowledge about risks “more important” than wrong partner selection	0
4:1 Lack of knowledge about risks “very strongly more important” than wrong partner selection	0
3:1 Lack of knowledge about risks “essentially more important” than wrong partner selection	0
2:1 Lack of knowledge about risks “weakly more important” than wrong partner selection	0
1:1 Lack of knowledge about risks “equally important “wrong partner selection	0
1:2 Wrong partner selection “weakly more important” than lack of knowledge about risks	3
1:3 Wrong partner selection “essentially more important” than lack of knowledge about risks	2
1:4 Wrong partner selection “very strongly more important” than lack of knowledge about risks	7
1:5 Wrong partner selection “absolutely more important” than lack of knowledge about risks	33
77. "Lack of Knowledge about Risks" and "Geographic Location" comparison.	
5:1 Lack of knowledge about risks “more important” than geographic location	1
4:1 Lack of knowledge about risks “very strongly more important” than geographic location	9
3:1 Lack of knowledge about risks “essentially more important” than geographic location	24
2:1 Lack of knowledge about risks “weakly more important” than geographic location	6
1:1 Lack of knowledge about risks “equally important “geographic location	2
1:2 Geographic location “weakly more important” than lack of knowledge about risks	1
1:3 Geographic location “essentially more important” than lack of knowledge about risks	1
1:4 Geographic location “very strongly more important” than lack of knowledge about risks	1
1:5 Geographic location “absolutely more important” than lack of knowledge about risks	0
78. "Wrong Partner Selection" and "Geographic Location" comparison.	
5:1 Wrong partner selection “more important” than geographic location	37
4:1 Wrong partner selection “very strongly more important” than geographic location	3
3:1 Wrong partner selection “essentially more important” than geographic location	5
2:1 Wrong partner selection “weakly more important” than geographic location	0
1:1 Wrong partner selection “equally important “geographic location	0
1:2 Geographic location “weakly more important” than wrong partner selection	0
1:3 Geographic location “essentially more important” than wrong partner selection	0
1:4 Geographic location “very strongly more important” than wrong partner selection	0
1:5 Geographic location “absolutely more important” than wrong partner selection	0
How much are you confident about your answers?	
1. Low	5
2. Medium	17
3. High	23
Would you like to add any comment or expand on any answer?	

Appendix 3

Case Study Plan

1. Research aim

The purpose of this case study in to provide deep understanding of the network related risk sources in the context of VO collaboration.

This study focuses on SMEs; it expected to provide an understanding of the network related risks and their implication on the partner and the whole VO.

Attention is paid to the risk weights, probabilities and dependencies (relationships) between risks sources.

2. Previous study summary

1- Based on deep literature review and expert's opinions 13 risk sources have been identified in the VO collaboration.
2- Through the second stage of the study which based on a questionnaire sent to the INTEROP-VLab members the risks sources have been related in direct and indirect relationships using the ISM (Interpretive Structural Modelling) technique to reach a model as shown in figure 1. In this case study we need to understand deeply these relationships and how strong are they?
3- Also based on questionnaire sent to the same expert's in INTEROP-VLab the weights (relative importance) of these risk sources have been found using the ANP (Analytic Network Process) technique. In this case study we are looking to study further these weights and probabilities associated with these risk sources for partners (and assess alternatives if possible).

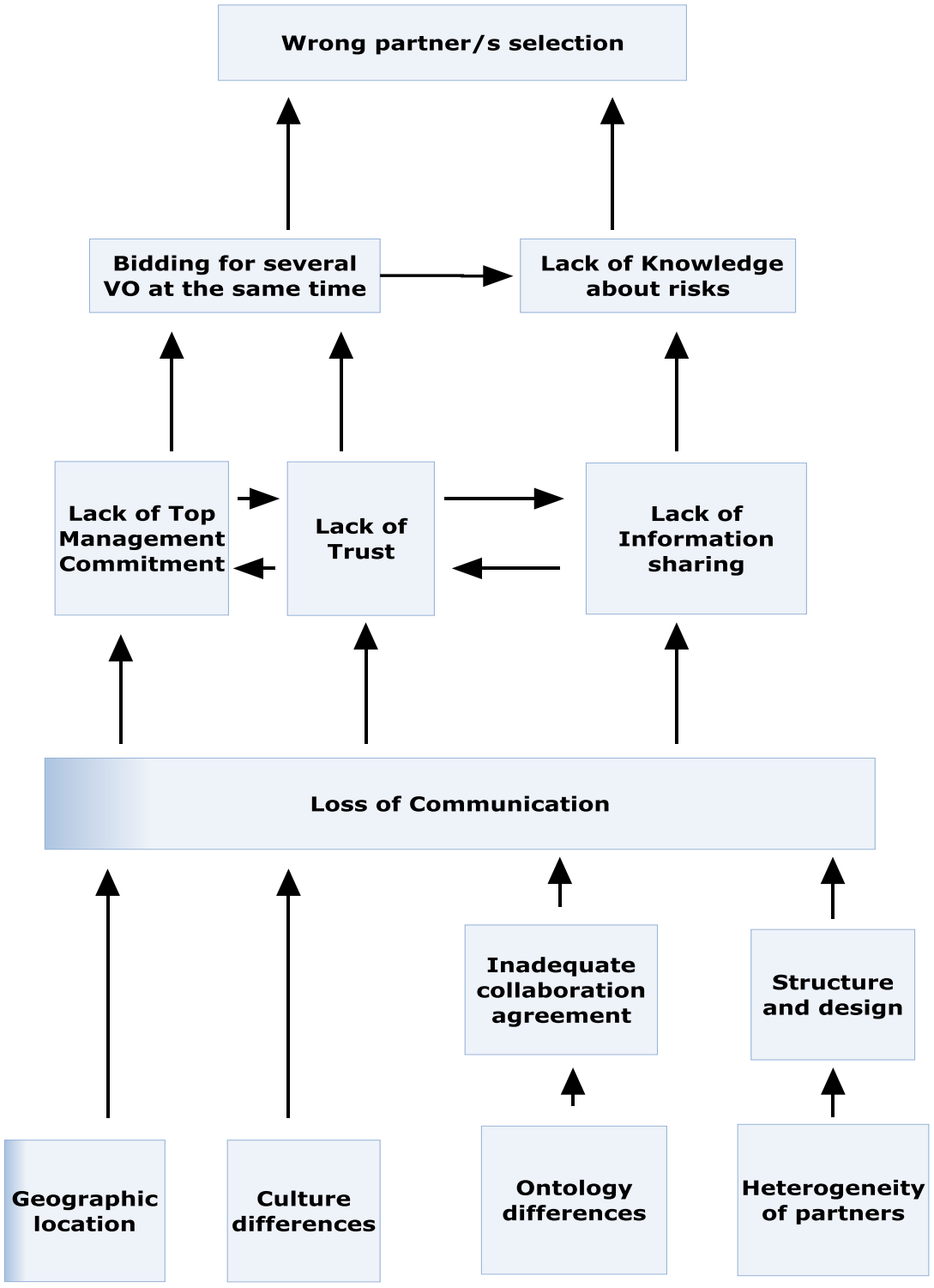

Fig 1 (ISM model) The relationships between risks sources

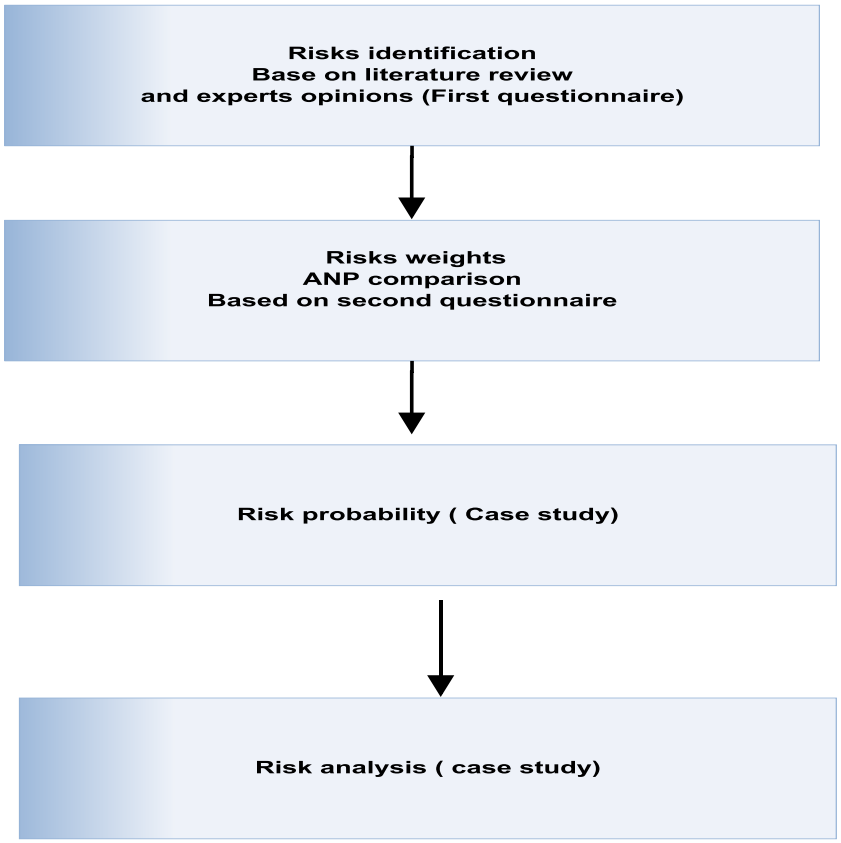

Fig 2 Research structure

3. Case study questions

3.1 General enterprise information

1) Size of the enterprise (number of employee, annual turn over).
2) Business structure and business unites of the enterprise.
3) Describe the business activities undertaken by the enterprise.

3.2 Collaboration activities

1) What is currently the structure of the VO (numbers of partners, areas of collaboration, requirements) has it changed the last years? In what way?
2) Describe your relation with a specific partner (history of relationship, areas of collaboration)?
3) What were the reasons for starting collaboration?
4) Describe the advantages and disadvantages for this relation?

5) How dependent do you consider your enterprise from the other enterprise? What will happen if the collaboration ends? What will be the consequence?
6) Compare the current situation with the past (the beginning of the relationship) has it changed? If yes in what way?
7) Did the members collaborate cooperate before? If yes, in what form? Did they know each other in person?
8) Does your network have a vision, a strategy and/or annual goals? If yes how set them and how? Can you outline the vision, strategy and goals?
9) Are there defined rules and agreements for the network?
10) What common activities do the network members have (training, workshops, visits, meetings, etc)? Do you think that these activities increase the flexibility of the members and decrease the risk?
11) How much do you trust the other enterprise? Has the level of trust changed during the collaboration? Any reasons for that?
12) How important and how strong is the trust between members? Is there any difference between original members and those who have joined later?
13) How does your enterprise make the collaboration decision?

3.3 Risks in collaboration

1) From your point of view what are the main risks sources related to the (network) collaboration decision?
2) What are the impacts of these risks sources? (Time, cost, quality and total failure) is there any other impact?
3) How much is it important to an enterprise success to understand and manage the risks sources in the collaboration?
4) How risk and rewards sharing has been evolved during your collaboration?
5) Do you have standardised any formal risk assessment techniques?
6) If you use of risks sources relation model (ISM) and risks weights technique (ANP) do you think that the probability and impact of risk will decrease?
7) Is there any case with alternatives to calculate the risks for each one?

3.4 Experience

1) Can you describe what is your role and activities within the network? Since you are broker/coach? How do you judge this role? Do you work for more than network?
2) Do you select the partners for the VO project? Do you use any techniques for the selection? Did you try to calculate the risk from each member before forming the collaboration or in the collaboration process?
3) Could you please give an overview of how many and what types of VO have been initiated in your network? How many partners tend to be involved? What is the average duration of a VO? Are there any factors which affect the duration of the collaboration?
4) Can you please describe the process of setting up a VO in terms of responsibilities, division of work and legal issues?
5) Describe the process of implementing VO collaboration? What types of problems arise and how did you deal with them?
6) Can you describe the termination of VO?
7) How often do you meet the partners?
8) How do you think the members of the network judge the add value of their membership and VO participation? Have they improved their flexibility, time to market, innovative capabilities or increase their product range?
9) Do you use any collaborative tools in general for VO collaboration? If yes can you describe them?
10) Which action should be taken in order to establish trust between VO members?
11) Which action should be taken in order to enhance information sharing?
12) Which action should be taken in order to increase the top management commitment of partners?

3.5 Understanding of the relations

1) How much you will loss communication if the partner geographic location is far away?

2) How much collaborating with a partner from different culture will affect the commutation between partners?
3) Is using different ontology's will influence the collaboration agreement?
4) Do u agree that the heterogeneity of partners (the partners incompatibility between system, syntax and semantic) will change the structure and design of the VO?
5) "Inadequate collaboration agreement will lead to loss of communication between partners" is this right?
6) Do you think that knowing the structure and design of the VO will make the communication between partners easier?
7) How much we need to increase the communication between partners to enhance the information sharing?
8) Is it possible to build trust without commutation between partners?
9) Do the managers increase their commitment with more communication?
10) Bidding for more than VO at the same time is an indication for no commitment from top management level, do you agree with this?
11) Is the relation between trust and top management commitment strong?
12) How much is the risk of losing IPR if you don't trust your partner?
13) Without trust a partner can bid for more than VO at the same time without having the capability to join them all, is that right?
14) Can you know about what are the risks threaten the VO without sharing information with partner?
15) Do you consider bidding for several VO at the same time without having enough capability to join all of them as a risk threatens the collaboration?
16) Do you believe that you can select the right partner for your collaboration without knowing the risks sources for this collaboration?

3.6 Risk comparison

For the risk calculation can you give us a probability for different partners?

Table 1

Risk Source	First experience	Second experience	Third experience
1- Lack of trust			
2- Wrong partner selection			
3- Information sharing			
4- Loss of communication			
5- Inadequate collaboration agreement			
6- Top management commitment			
7- Heterogeneity of partners			
8- Ontology differences			
9- Structure and design			
10- Knowledge about risks			
11- Culture			
12- Bidding for several VO at the same time			
13- Geographic location			