For Werner

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THE SOCIO-CULTURAL CHALLENGE OF EFFECTIVE KNOWLEDGE MANAGEMENT IN VIRTUAL PROJECT ENVIRONMENTS

A Dissertation submitted by

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ABSTRACT

The growing popularity of inter-organisational alliances combined with a growing tendency to flatter organisational structures and globalisation, has accelerated the need for firms to coordinate activities that span geographical, as well as organisational boundaries utilising virtual project teams. This focus on virtual working environments evolved in parallel with another major trend, because over the last decade many organisations have recognised the importance of managing their intangible assets. Knowledge work is rapidly becoming the dominant type of work in the post-industrial economy and the ability to deliver knowledge leadership within challenging working environments like geographically dispersed knowledge teams will be one of key success factors in the future. Focusing on projects as one of the most common 'vehicle' for inter-organisational activities it will become increasingly important for the involved organisations to take steps to capture and build on the learning that takes place during a project. However, there is limited empirical research from a knowledge perspective of managing multi-location project teams whose work is highly complex in nature and a membership mix of internally employed personnel as well as external partners and/or other contract "staff". In this context the dissertation analyses the following question:

> *How do socio-cultural enabling conditions and network-related factors influence knowledge creation and exchange in virtual project teams?*

The research issues which have been investigated target the aspects of trust, shared language and a common vocabulary, informal networks, boundaries and risk associated with uncontrolled (boundary-spanning) knowledge exchange. Based on its explanatory nature this research operates within the scientific paradigm of critical realism. A multi-method case study approach utilising different interview techniques in combination with social network analysis (SNA) has been used. Data collection involved six international case study settings comprising virtual project teams with mostly multi-cultural members from Europe, America, Australia, Africa and Asia. Research participants included private, governmental and non-profit organisations from the IT, telecom, engineering, airline and environmental sectors. Additional systematic input from an interdisciplinary mix of more than 29 knowledgeable business professionals and international academic informants has been incorporated in this study.

Research findings revealed differentiated forms of *trust* developed among virtual team members, thus in technical (operational) environments task-related trust is more prevalent between members, whereas on a more managerial level, interpersonal trust emerges as the primary from of trust. Evidence could be found that very often psychological distances between virtual team members and not physical distances are the most influential factors causing communication gaps and an inability to share knowledge. Based on SNA results, five out of six cases included individual team members with a measurable difference between the potential accessibility of their knowledge and an incurred cost perceived by others of accessing their knowledge. Focusing on the aspects of *vocabulary and language* two thirds of the participants experienced communication problems in their virtual projects and 42 per cent of the interviewees reported negative experiences or problems focusing on knowledge sharing and utilisation. Despite the identified communication problems, 63 per cent of the participants claimed that they share a common language in their virtual project team - technically as well as personally.

Notwithstanding the notion of some authors that *social networks* are the most important vehicles for information and knowledge exchange, the majority of participants assessed the formal project as the primary driving force. Nevertheless SNA findings demonstrated that network ties are useful predictors of how information and knowledge flows in virtual project teams and can be better indicators than formal project structures. In this context, interview findings revealed that on average team members searched around 13 hours per week for necessary information and knowledge and that a general preference for obtaining information from other people, rather than from documents prevailed. Further statistical evidence showed that not-collocated team members meet every 71 days during joint face-to-face project meetings.

Interview findings pointed out that there is a difference between team members who just do their jobs and *boundary* spanners who can bring in new and on-demand knowledge from other areas, thus strengthening a project's reactiveness in dynamic and challenging situations. The application of SNA allowed the in situ calculation of brokerage positions within all investigated virtual project teams, thus supporting the common wisdom that personal networks (those you know) often has a great deal to do with content knowledge (what you come to know). Focusing on individual skills and competences, participant feedback highlighted the significance of project managers to be socially connective, thus linking small collocated cliques within the surrounding virtual fabric, especially in multicultural and interdisciplinary environments. Hence, in these types of project settings the character of an appropriate job profile of project managers shifts more and more from the managerial, procedural 'mechanic' to a socio-cultural empowered integrator of distributed minds. Nearly all interviewees (95 per cent) emphasised the need for additional socia-cultural and tool-related skills and characterised the 'ideal' virtual team member as open minded, proactive, flexible and positive person with good communication skills.

Two thirds of the interviewees claimed that they were not aware of any knowledge losses with respect to their actual project, although 50 per cent stressed that knowledge is always lost in either virtual or traditional project teams. Research findings supported the notion that project parties may have, deliberately or unconsciously, different perspectives on the direction and boundaries of the knowledge component in their exchange relationship. Referring to knowledge management in multi-institutional, multicultural project environments the analysis revealed several *risks* e.g. insecure property rights, loss of integrity during translation of codified knowledge or the fact that internal organisational guidelines of involved project partners may overrule project targets. In most investigated case environments reflective learning was not valued and not implemented systematically, thus knowledge was not secured and therefore lost, because of a primary focus on immediate (task or project-related) problem solving, however neglecting its organisational and long term importance as 'fuel' for cross-project and organisational learning processes.

The calculation of specific case-related SNA indices enabled the informal assessment of each team member's prestige, activity and influence, thus allowing much more accurate interventions targeting the optimisation of information and knowledge sharing processes. In this context, research findings suggested that its very often socially-enabled tacit knowledge, what ensures the necessary reactivity and flexibility in challenging project situations. Given its contextual limitation and natural decay factor a primarily codification oriented knowledge management approach is doomed to fail in highly dynamic and heterogeneous work settings. Findings derived from qualitative as well as quantitative data showed that participants valued virtual projects as ideal learning environments, nevertheless the analysis also revealed that that virtual work [and related knowledge management], compared to traditional project settings, often puts additional stress on team members. A correlation analysis of SNA-related variables identified several significant relationships, e.g. the extent to which a team member seeks information or knowledge from another individual is positively related to the aspects of ‘Knowing’, ‘Value’ and ‘Access’. In contrast, the variable ‘Cost’ is negatively related, hence if the cost level increases information and knowledge sharing activities decrease. A mediation of information and knowledge sharing by team member gender and tenure could not be confirmed, whereas the variables ‘Proximity’ and ‘Sub-group membership’ influenced sharing processes in 50 per cent of the investigated case environments.

In summary and given the dynamic and interconnected socio-cultural aspects investigated, this theory-building research showed that knowledge management in virtual environments is more complex than common business practice suggests. In contrast with organisations, which are supported by structure, routines and a comparably stable workforce to absorb knowledge, virtual projects miss any natural transfer mechanisms. The research showed that that many teams [and the involved parent organisations] tend to look at virtual project teams and related knowledge management through the filters of the old paradigm thus keeping the old models and old language in place. The nature of relevant knowledge objects, thus either tacit or explicit, and their transferability were not sufficiently taken into account. Nevertheless, projects are guided by the constraints of time, budget and quality, which make the reuse and harnessing of knowledge a necessity. But organisations often launch new initiatives without understanding the inner working of involved formal and informal networks, relying on the philosophy that more communication and collaboration are better.

Based on the comprehensive repository of research findings, a tripartite conceptual framework has been developed. The framework builds both on a rational and a more informal project dimension and describes the link between a collaborative and a content–focused lifecycle. It further defines a virtual project as socio-culturally networked system using quantifiable parameters and conceptualises an integrative approach focusing on knowledge representation and moderation. This new holistic model supports a deeper understanding of the complex, dynamic sharing processes in virtual project environments and provides a starting point regarding the optimisation of project guidelines and policies. Further, it might act as ‘embryonic cell’ fostering new and innovative perspectives focusing on knowledge management in virtual project teams.

Keywords: Virtual project team, Knowledge Management, Informal Networks, Social Network Analysis, Language, Boundaries, Risk, Trust

Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

Signature of Candidate　　　　　　　　Date

ENDORSEMENT

Signature of Supervisor　　　　　　　　Date

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I would like to thank the members of the project teams for taking part in this research and corporate management of the involved organisations for sponsoring this work. Confidentiality constraints do not allow me to acknowledge in name the numerous individuals who took part in the interviews and surveys. However, I would like to express my heartfelt thanks to the people who gave so willingly of their time to partake in this investigation.

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Frank D. Behrend
Duesseldorf, December 2005

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1 INTRODUCTION

1.1 Background and Significance of the Research

"Those who are not confused today have not understood the problem."
[Jack Welsh, Ex-CEO General Electric]

One of the greatest challenges for businesses today is managing the impact of the profound changes taking place in the global economy. Global players form inter-organisational alliances and many small businesses are gradually becoming part of a much larger matrix of interactive network organisations. This development, combined with a growing tendency to flatter organisational structures and globalisation, has accelerated the need for firms to coordinate activities that span geographical, as well as organisational boundaries (Townsend et al. 1998). Evidence of this development has been found in a variety of work contexts, such as the use of physically dispersed project teams in software development environments (Hackman & Walton 1986). These structures are characterised by such terms as virtual, boundary-less, or networked (Davidow & Malone 1992; Galbraith 1995; O'Hara-Devereaux & Johanson 1994).

This focus on virtual working environments evolved in parallel with another major trend, because over the last decade many organisations have recognised the importance of managing their intangible assets. The ability to build and leverage the value of these intangible assets constitutes a core competency for organisations, especially those providing financial and professional services. In these knowledge-intensive organisations, processing knowledge is central to business success (Drucker 1988; Prahalad & Hamel 1990). Knowledge work is rapidly becoming the dominant type of work in the post-industrial economy and the ability to deliver knowledge leadership within challenging working environments like geographically dispersed knowledge teams will be one of key success factors in the future (Newman 1997).

Focusing on projects as one of the most common 'vehicle' for inter-organisational activities Smith and Dodds (1997) predict that it will become increasingly important for the involved organisations to take steps to capture and build on the learning that takes place during a project, as there will be fewer permanent core staff to act as the repository of organisational learning. However, there is limited empirical research from a knowledge perspective of managing multi-location project teams whose work is highly complex in nature and a membership mix of internally employed personnel as well as external partners and/or other contract "staff". With knowledge as the new strategic resource, it might be of great strategic interest for firms or organisations to identify and manage those factors in virtual project teams supporting knowledge creation and transfer leading to sustained advantage as well as controlling possible “knowledge leaks” weakening the own position on the log run.

1.2 Research Question and Issues

Based on the conducted literature review (see chapter 2 for details) and succeeding convergent interviews with academic experts and knowledgeable practitioners (see chapter 3 for details) the following general **research question** emerged:

> *How do socio-cultural enabling conditions and network-related factors influence knowledge creation and exchange in virtual project teams?*

Essentially I argue that knowledge management in virtual project environments is a heterogeneous and complex phenomenon and that holistic, but context-specific strategies are necessary to support knowledge generation and exchange. The subsequent **research issues** have been identified (see section 3.3 for details) and will be explored in detail to address the research question with sufficient depth and focus:

RI 1: How do the level and type of trust within a virtual project team affect the creation and exchange of knowledge?

RI 2: How can a shared language and a common vocabulary impact knowledge management in virtual project teams?

RI 3: To what extent do informal networks influence the knowledge creation and exchange in virtual project teams?

RI 4: How do boundaries support or hinder knowledge creation and exchange?

RI 5: What are the risks associated with limited awareness regarding the quality of the existing knowledge repository and uncontrolled knowledge diffusion processes in virtual environments?

1.3 Justification of the Research

Importance and future relevance of virtual project teams

A decade ago, virtual project teams were almost nonexistent. Today, technology, globalisation, and the need for fast responses to marketplace demands have dramatically changed the way business is conducted. Research done by the Gartner Group reveals that the use of global, virtual work settings is going to increase significantly (Solomon 2001 – see Table 1-1):

Table 1-1: Projected use of global, virtual work environment

Employee's time:	Year 2000	Year 2010
- working alone	40%	30%
- working in the same time zone and in the same place	15%	5%
- working in a different place at the same time	15%	25%
- working at a different place and different time	30%	40%

Source: adapted from Solomon (2001)

Gaps in literature

Holthouse (1998) stressed that research on how tacit knowledge can be identified and utilised despite increasing forces that are disrupting the social nature of the workplace community has to be high on the research agenda. Although this is especially true for virtual project teams as a new and expanding working concept, the corresponding body of knowledge shows significant gaps. Jarvenpaa and Leidner (1999) requested more systematic research on virtual team member characteristics and Schindler (2001) noted the missing operational and parametric definitions of appropriate knowledge focused member roles. Much of existing past and present research is based on teams, either normal or virtual, but primarily within organisational structures and not related towards appropriate project environments. Further, much of the literature focuses on knowledge processes in teams within one single organisation, but only very few investigated more representative settings involving virtual project teams and external firms, partners or networks. Finally, established project methodologies like IPMA

(2003), PMI (2003) or PRINCE2 (2002) provide no and insufficient guidance targeting virtual teaming and the management of intellectual assets.

Possible benefits of outcomes

According to Probst and Buechel (1998) project organisations are well suited as learning environments and Nonaka and Konno (1998) stressed that knowledge creating teams and projects will play key roles in organisational value generation. This study will investigate possible relationships between socio-cultural factors like trust, language or informal groups and the effective knowledge creation and transfer in the context of virtual project teams. Due to the present and future significance of this working concept and focusing on knowledge as the organisational asset, the corresponding findings of this research will be of theoretical as well as practical value, thus targeting not only the international research community, but also the appropriate managerial domain.

1.4 Research Methodology

Based on its explanatory nature this study of knowledge management in virtual work environments operates within the scientific paradigm of critical realism (see chapter 4.2 for details). The primary research approach for this study has qualitative character and will make use of the inductive theory-building case study methodology incorporating convergent and in-depth interview techniques. This approach is well suited to ensure the necessary contextual understanding and the achievement of empathetic objectives through a direct, first hand, more or less intimate analysis of the research setting. A multiple case study approach will be used in this research because it has several advantages compared to a single case study design (see chapter 4.5.2 for details). In particular, the triangulation of data using multiple sources of evidence enables replication for theory generalisation.

Nevertheless due to the challenging area of research (dynamic social processes within a virtual environment), weaknesses of the case study methodology (see Table 4-2) and specific data collection procedures (see section 4.6), the qualitative methodology will be supplemented by an embedded Social Network Analysis (SNA) (see chapter 4.3 for details). SNA methodologies provides a rich and systematic means of assessing informal networks by mapping and analysing relationships among individuals, teams or organisations (Wasserman & Faust 1999). Through the combination of the discussed methods the robustness of results can be increased; findings can be strengthened though cross-validation achieved when the different kinds and sources of data converge and are found to be congruent, or when explanation is developed to account for differences.

Building on Miles and Huberman (1994) as well as Yin (2003) the necessary primary data for the qualitative part of the data collection has been gathered from several sources such as convergent interviews, depth interviews and case-related documents. Telephone-based depth interviews represented the major source of data used in this research because they provided valuable insights regarding the five research issues (see section 4.6.3.1 for more details). Referring to Zikmund (2000) the quality of data obtained by telephone-interviewing may be comparable to that collected in personal interviews. In contrast to the interviews which were conducted with selected team members, the whole virtual project team filled out the web-based SNA questionnaire (see section 4.6.3.2 for more details).

Anonymity was agreed upon for all participating companies and organisations as well as all involved team members. The respondents were assured that the research results would not be used for purposes other than academic knowledge and advancement (see section 4.10 for more details). Finally, ethical considerations were incorporated into the research design from the beginning, based on the ethical guidelines of the Research and Higher Degrees Committee of the University of Southern Queensland.

1.5 Delimitation of the Scope and Key Assumptions

The *scope* of this study is limited as only six virtual project teams are studied. Furthermore, the investigated teams cover only five industries, namely IT, Environmental research, Telecommunication, Airline and Engineering / Logistics. Hence, the research findings as well as the developed multi-method approach will form part of a base that can be used to build further explanatory research targeting knowledge management in virtual project environments. In addition, a researcher may have some emotional attachment to particular ideologies and a tendency to come up with an answer before the research, resulting in the use of research for justification of a preconceived idea. Acknowledgment of this tendency, a clear focus on the research issues than the industry, a comprehensive literature review in combination with convergent interviews and working closely with the academic supervisor and industry informants limits this effect.

One *assumption* of this study is that the internal definitions of the term 'project' are comparable across the participating organisations, thus the investigated virtual projects represent unique undertakings which have to be completed by a certain date, for a certain amount of money, within some expected level of performance. Project characteristics, that all together are assumed, are a temporary nature, with specified end-results, and a non-recurrent character, with complexity and significance (Koskinen et al. 2003).

1.6 Structure of the Dissertation

A seven chapter structure has been developed to present this dissertation in an effective and comprehensible manner. The *first chapter 'Introduction'* outlines the broad field of the study and leads into the focus of the research problem. The research question and corresponding research issues are presented and an introductory overview of the methodology is given. Finally, key and controversial terms are defined and delimitations of scope provided. The *second chapter "Literature Review"* builds the necessary theoretical foundation by reviewing the immediate field of the research problem as well as related to parent disciplines like Knowledge Management, Social Networks and virtual work environments. This part of the dissertation ends with a summary of identified key issues which forms the basis for the selection of research issues and the development of a theoretical framework.

Due to the complexity and heterogeneity of the investigated phenomenon the *third chapter "Theoretical Framework"* describes the use of convergent interviewing to discover new dimensions of the research area and to refine the preliminary research question and corresponding research issues. The *fourth chapter "Research Methodology"* discusses and justifies the research design and the methodology used to collect the field data to address the identified research issues. The developed multi-method case study approach utilising interview techniques and social network analysis (SNA) will be described in detail. Building on that the process of data collection as well as the pilot case study are discussed. Finally, limitations to the study and ethical considerations are addressed.

The *fifth chapter "Results: Analysis of interview data"* presents results and findings derived from qualitative interview data, highlights patterns and analyses them for their relevance to the research issues. Data display is clearly structured around the research issues and frequent summary tables and figures of results are used to enhance readability. The *sixth chapter "Results: Social Network Analysis"* displays results calculated from quantitative data collected using the developed web-based survey. The case-by-case analysis sequence starts with an investigation of project-based information and knowledge sharing activities and then additional SNA variable-related characteristics and finally SNA cross-variable aspects will be addressed. The *seventh and final chapter "Conclusions and implications"* presents findings for each research issue within the context of prior research examined in the literature review. A cross-method synthesis will support the identification of obvious patterns and tentative relationships combining relevant findings from the previous two analysis chapters around the five research issues as well describing significant case-related results. In addition, the chapter incorporates qualitative findings about the research problem developed during the dissertation and implications for theory, practice and methodology as well as limitations that came apparent during the process of the research are discussed. The last section of this chapter exhibits implications and suggestions targeting the selection and design of further research.

1.7 Key Definitions and Terminologies

This section provides the basis for the subsequent parts of the dissertation by defining and contrasting key and controversial items and concepts. The Virtual Project Team (VPT) as the underlying core construct of the research inquiry will be introduced and explained.

1.7.1 Contrasting data, information and knowledge

It is important to emphasise that data, information, and knowledge are not interchangeable concepts. Referring to Davenport and Prusak (2000) organisational success and failure can often depend on knowing which of them is needed, which the researcher has, and what the researcher can and can't do with each. *Data* is a set of discrete, objective facts about events. There is no inherent meaning in data; it provides no judgement or interpretation and no sustainable basis for action. *Information* can be described as a message e.g. in the form of a document or an audible or visible communication and has a sender and a receiver. Information is intended to change the way the receiver perceives something, to have an impact on his judgement and behaviour. Unlike data, information has meaning; it is organised to some purpose. It should be mentioned that one should not confuse information – or knowledge – with the technology that delivers it. The medium is not the message, though it may strongly affect the message.

Historically, there have been two traditions for thinking about *knowledge* as well as more recent approaches to integrate the two streams of thought (Nonaka & Takeuchi 1995). The first is rationalism, which sees knowledge as something to be obtained deductively via some mental process, and the second is empiricism, which sees knowledge as something to be obtained inductively via experience (Rubenstein-Montano et al. 2001). The notion of integrating these two traditions in defining knowledge is seen in the philosophical tradition of pragmatism, where thought (rationalism) and action (empiricism) relate interactively (Dewey 1929).

Sveiby (1997) describes knowledge as tacit, as action-oriented, as based on rules, as individual and as constantly changing. Nonaka and Takeuchi (1995) go further and consider knowledge as a dynamic human process of justifying personal belief towards the 'truth'. Davenport and Prusak (2000, p. 5) offers a pragmatic working definition of knowledge that will be used throughout this dissertation:

> *Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms.*

In addition to defining knowledge, knowledge is typically classified as either tacit or explicit. This distinction refers to Polanyi's (1962, 1975) work on tacit knowledge and has been popularised by Nonaka (1991, 1994) and Nonaka and Takeuchi (1995). *Explicit Knowledge* can be codified if it can be recorded or transmitted in the form of symbols (e.g. writing or drawings) or embodied in a tangible form (e.g. machinery or tools). It can be represented, stored, shared, and effectively applied (Roberts 2000). *Tacit knowledge* is non-codified knowledge that is acquired via the informal take-up of learning behaviour and procedures; it is often referred to as know-how. This type of knowledge is that which is difficult to express, represent, or communicate. Nonaka and Takeuchi argue that knowledge can be converted from tacit to explicit and vice versa. The social interaction between these two types of knowledge leads to the creation of new knowledge and innovation.

1.7.2 Knowledge Management

In its broadest sense, *knowledge management* (KM) is the ability to leverage intellectual capital for achieving organisational goals (Rubenstein-Montano et al. 2001). Quintas et al. (1997) argue that knowledge management does not mean managing everything that is known, but it is concerned with creating and mobilising certain knowledge for certain purpose. Laudon and Laudon (2000) define knowledge management as a process of systematically and actively managing and leveraging the stores of knowledge in an organisation. Chase (1999, p. 35) emphasises the difference between existing and potentially new knowledge and describe knowledge management as “achieving organisational goals and superior performance, organisational creativity, operational effectiveness and excellence in products and services through leveraging of new knowledge and existing organisational knowledge”.

In his definition Uit Beijerse (1999, p. 97) stresses the implicit character of knowledge management: “Knowledge Management is achieving organisational goals through the strategy driven motivation and facilitation of (knowledge-) workers to develop, enhance and use their capability to interpret data and information through a process of giving meaning to these data and information”. All cited definitions of knowledge management picture the fuzziness and divergence associated with this relatively new discipline. To ensure the necessary common understanding the following definition will be used within the context of this dissertation:

> *Knowledge Management is the holistic and systematic approach to optimise those processes targeting tacit and explicit knowledge assets aimed at the creation of intrinsic value in a given socio-cultural system.*

1.7.3 Projects: Definition and Scope

A *project* is an organisation of people dedicated to a specific purpose or objective. Projects generally involve large, expensive, unique, and high risk undertakings which have to be completed by a certain date, for a certain amount of money, within some expected level of performance. At a minimum, all projects need to have well defined objectives and sufficient resources to carry out all the required tasks. Project characteristics, that all together are needed, are of a temporary nature, with specified end-results, of a non-recurrent character, with complexity and significance (Koskinen et al. 2003).

1.7.4 Characteristics of a virtual team

A *virtual team* in this study is seen as a pool of experts that temporarily band together to tackle some customer or organisational need. Davidow and Malone (1992, p. 57) describe the formation of such teams as "something like atoms temporarily joining together to form molecules, then breaking up to form a whole new set of bonds". Henry and Hartzler (1998, p. 5) define *virtual team*s as "groups of people who work closely together even though they are geographically separated by miles or even continents" and as "intact workgroups or cross functional groups brought together to tackle a project for a finite period of time through a combination of technologies". While Lipnack and Stamps (1997, p. 7) describe a *virtual team* as "a group of people who interact through interdependent task guided by common purpose" and "works across space, time, and organisational boundaries with link strengthened by webs of communication technologies". Both definitions emphasise that virtual teams are geographically dispersed, driven by common purpose, enabled by communication technologies and involved in cross-boundary collaboration. Although not giving a formal definition for the term, Duarte and Snyder (1999), Fisher and Fisher (1998) and Haywood (1998) do characterise *virtual team* in a similar way (Bal & Teo 2000).

In addition to the mentioned common criteria that define a virtual team, three of the cited authors also further expand the characteristics that a virtual team should possess (Bal & Teo 2000). Lipnack and Stamps (1997, p. 128) do not give a specific number for the size of a virtual team but they do point out that virtual teams tend to have a "small number of active members and large memberships". Henry and Hartzler (1998, p. 5) state that virtual teams usually consist of not more than 20 members. However, Lipnack and Stamps (1997, p. 128) argue that team size should depend on "tasks at hand and constraints and opportunities of the situation", and therefore it is inappropriate to define one "right" size for teams. According to the authors there are always new people joining the team and other member's leaving the team throughout the team life cycle. Fisher and Fisher (1998) identify inconsistent membership as also one of the key characteristics of virtual teams. They uniquely use the term (p. 131) "virtual knowledge team" to imply that members of a virtual team are usually knowledge workers. According to Bal and Teo (2000) this is one aspect of characterising a virtual team that is conspicuously missing among the other authors. The following Table 1-2 summarises the above mentioned characteristics of virtual teams:

Table 1-2: Characteristics of Virtual Teams

• team members are goals oriented
• members are dispersed geographically (nationally or internationally)
• the team works apart more than in the same location
• the team is a collection of individuals who work together to attain goals by using computer-supported networking
• team members are involved in a coordinated undertaking of interrelated activities
• members are mutually accountable for team results
• team members solve problems and make decisions jointly
• they are of finite duration, with beginning and ends (few teams are permanent)

Source: Bal et al. (2000)

Due to the global scope of the present economic environment many organisations use projects as a mean to coordinate geographically distributed activities. The next part of the chapter will provide a definition and common characteristics of this organisational form and its management.

1.7.5 Defining the core construct: Virtual Project Teams

A *virtual project team* (VPT) is a conduit for delivering large strategic, operational or commercial undertakings whose activities are co-located across various geographical localities (Lee-Kelley 2002). It may consist of several organisations or outsource partners as well as skilled employees. Team membership is unlikely to be centrally located or working for a single company, especially when partners are involved. At the centre is the essence or "hub" of the company (Dickerson 1998). Handy (1995a) locates the main aim of such a "shamrock" shaped organisation as economic cost sharing by outsourcing non-core activities to third parties or employing part-time and temporary workers. In the context of this study the following definition will be used:

> *A virtual project team (VPT) is a group of interdependent knowledge workers who share responsibility for completion of large strategic, operational or commercial undertakings and are geographically dispersed, thus interacting primarily through information and communication technologies.*

A VPT adds more flexibility and agility to an organisation and expands the possible ‘option list’ for the corporate managers. Indeed, it is increasingly a common practice among skilled professionals to "work" for a variety of (usually non-competing) firms offering their knowledge and skills on projects but, essentially being their own masters (Oates 1998). Often, the knowledge worker is employed by one company (the outsource agent or broker) but in fact applies his/her expertise on a day-to-day basis, for the benefit of another organisation (the client), i.e. serving as a virtual member of the client's project organisation. To overcome constraints of geographical and time differences, there is likely to be extensive deployment of technology for information, communication and coordination purposes. But in real world settings VPT face much more challenges than just the two mentioned ones – the next chapter will provide further insights on this issue.

1.8 Summary

In summary, this chapter laid the foundation for the main part of the dissertation. It introduced the research problem and research issues. Then the approach was justified, definitions were presented, the methodology was briefly described and the overall structure was outlined and limitations were given. On these foundations, the report can proceed by building the necessary theoretical / conceptual base for the research.

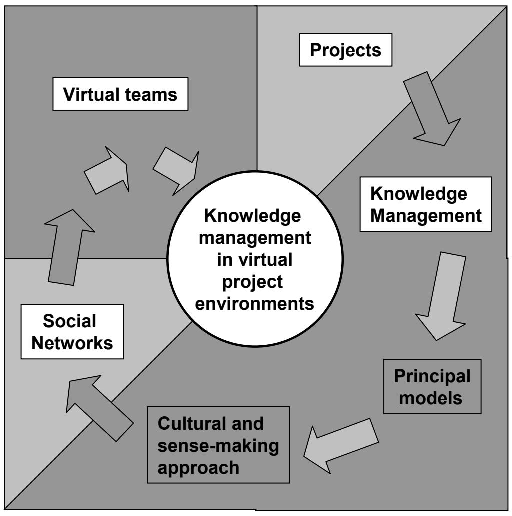
2 LITERATURE REVIEW

2.1 Introduction

"Believe nothing, no matter where you read it, or who said it, no matter if I have said it, unless it agrees with your own reason and your own common sense"
[Buddha]

After having identified and explained the research problem, this chapter aims to build the theoretical foundation upon which the whole dissertation is based by reviewing the relevant literature. Based on the interdisciplinary and comprehensive character of the area of interest the literature survey will be extended beyond the original boundaries of the research problem. In this context, uncovering research issues that are controversial and have not been answered sufficiently by previous researchers is the primary purpose of this part of the dissertation. While focusing on the immediate discipline of 'Knowledge Management in virtual project environments', existing theories and models referring to important parent disciplines will be presented and discussed (see Figure 2-1).

Figure 2-1: Analytical structure of literature review



Source: Developed for this research

First, extant approaches focusing on projects as a work form and its sometimes challenging management will be addressed; simultaneously identifying its knowledge intensive character. Then, primary knowledge models and corresponding knowledge roles and skills will be presented; contrasting Newtonian and more social-cultural based perspectives and models. Next, based on a [social] network view of knowledge relationships, appropriate theory as well as a corresponding research tool will be introduced; supporting the examination of information / knowledge flows and the analysis of emerging patterns. Finally, before surveying the literature targeting the immediate discipline, relevant aspects of virtual team environments, e.g. their challenges, goals and drivers and an associated life cycle model will be presented.

2.2 Projects and its Management

2.2.1 The rise and importance of Project Management

Largely unremarked in critical circles, Project Management (PM) has spread in recent years from its traditional dominance of the fields of construction and engineering into sectors as diverse as education, IT, media, health care, and surgery (Hodgson 2002). The rise of the professional Project Manager has taken place on the back of a number of contemporary tendencies in work organisations, including the use of IT to restructure business processes (Hammer & Champy 1995), the current popularity of 'self-managing work teams' (Manz & Sims 1987), the flourishing interest in 'knowledge workers' (Blackler 1995) and the emergence of the project-based organisation (Hobday 2000). Increasingly, the field of Project Management has promoted itself as a universal and politically-neutral toolkit of techniques appropriate for any type of activity in any sector, enabling the tight control of discontinuous work processes, with particular potential for the control of expert labour.

Project Management first came to popular attention in the management literature in the late 1950s although its 'heyday' is widely seen to be the late 1960s and early 1970s (Winch 2000). In brief, Project Management promises a system which can deliver 'one-off' undertakings 'on time, to budget, within scope' (Morris 1997), through the planning and control of variables including resources, cost, productivity, schedule, risk, and quality. Arguments behind the promotion of Project Management techniques have remained remarkably similar over a long time, referring to the increasing uncertainty and complexity of the modern world (e.g. Cleland and King 1968; Kerzner 1995). In this context Hodgson (2002) argues that despite the proclaimed novelty of the Project Management approach, most textbooks return to the year 1916 and Fayol's *Elements of Management* when attempting to define the responsibilities of the project manager: Planning, Organising, Commanding, Co-ordinating and Controlling.

Despite trenchant critiques of these principles from a number of writers (e.g. Hales 1986, Mintzberg 1973), they are evident in slightly adapted forms in the vast majority of Project Management guides. Thus Morris states unequivocally that Project Management is the same as 'any other kind of management, except that one moves through a predetermined life cycle. Everything else, at this level, is covered by general management practices - planning, organising, controlling and so on' (1994, p. 307). In contrast, Bredillet (2004) provides a much more differentiated view targeting organisational operations and projects. According to the author every organisation acts according to two fundamental modes. The *operational mode* aims at the exploitation of competitive advantage and current position on the market and provides profits and renewal or increase of resources. The entrepreneurial mode, or *project mode*, focusing on the research of new position and new competitive advantage, consumes money and resources (see Table 2-1 for details).

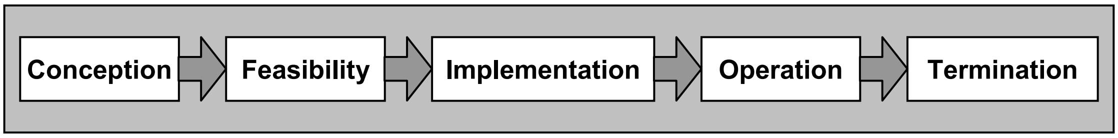
Table 2-1: Characterisation of [organisational] operations vs. projects

Operations	**Projects**
○ Ongoing and repetitive activities, Being prone to influence of numerous factors; ○ Reversibility of operations can occur within economically acceptable limits; ○ Factors of influence are mainly internal (endogenous) rather than environmental and they can be manipulated by the operation manager; ○ Environmental factors explain only a low part of the fluctuation of outputs; the inputs present random variations; ○ The variation of inputs can be made statically stable; future effects can be predicted with a specified margin of error; ○ Non usual variations coming from perturbations external to the operation lead to slight penalising and never to disaster	○ Non-repetitive activities, one-shot; ○ Decisions are irreversible; ○ Projects are subjects to multiple influences; the main influences come from environment (exogenous) and may vary considerably; ○ Decision-maker cannot usually handle an important number of variables (exogenous variables); ○ Project is generally not in statistical stability and it is not possible to associate probabilities to the effects one try to measure; ○ A "bad" decision and/or a non controllable influence of a major event may lead to catastrophic result.
Operations involve: • Planed actions • Masked actors • Process • Rational • Algorithmic • Anhistoric • Cooperation • Stable and making one feel secure	Projects involve: • Creative actions • Unmasked actors • Praxis • Para-rational • Mosaic • Historic • Confrontation • Rich, ambiguous, instable

Source: Bredillet (2004)

The key effect of the application of Project Management models and techniques is enhanced control over the conduct of employees, based on the objectification of those subjects involved in project work. As Metcalfe argues in one of the few critical studies of Project Management, the quantification and detailed planning involved in Project Management serves to 'enhance the "calculability" of individuals through developing measures of routine predictability and control' (1997, p. 309). This calculability is largely made possible by the delineation of a general model for the process of project work, which is commonly defined as the *Project Life Cycle*, or PLC, although in reality it is more a sequence of phases reaching from the start to the end of the project. This model (see Figure 2-2), in common with the models in most other Project Management texts, includes five basic phases, here defined as: Conception, Feasibility (including Definition and Development), Implementation, Operation and Termination.

Figure 2-2: Traditional Project Life Cycle



Source: Hodgson 2002

In summary it can be argued that a key intention of traditional Project Management models and techniques is to enhance the calculability and visibility of those engaged in project work, enabling a direct form of control. The next section describes current perspectives and associated approaches focusing on projects and its management.

2.2.2 Extant approaches to project management

Traditionally, as depicted in the last chapter, project management has been synonymous with the management of the delivery process and, in particular, time, cost, and quality aspects of projects. In this context, Webb (1996) argues that these traditional PM approaches only partially fulfil all the objectives of a project and that new models, philosophies, and methodological frameworks should all tie in the issues and external factors that affect projects. Jaafari and Manivong (2000) propose a basic shift from the traditional objectives of cost, time, and quality to life-cycle objective functions, such as return on investment, facility operability, and life-cycle integration. In addition to the already introduced traditional (or conventional) approach to project management the authors identified two new perspectives, which are better suited to cope with dynamic and complex business demands.

The *alliance approach* to project delivery is a long-term relationship between two or more companies that have aligned interests over a specific range of activities, hence forming a platform for virtual knowledge activities. Thus there is close cooperation to develop long-term shared objectives. The *Life Cycle Project Management (LCPM) approach* is based on setting up multi-disciplined – more and more virtual - concurrent teams working under the overall direction of project manager in a project alliance set-up. Each team is assigned a part of the project for which it is wholly responsible, from definition through handover. Project management will have an overriding and integrating role in the development and implementation of the project concept and details. Referring to the primary area of interest, thus 'Knowledge Management on virtual project environments', all three introduced PM approaches will now be shortly discussed and contrasted from a communication and information point of view.

2.2.2.1 Conventional project management

Project information and integration management plays a critical role in the successful project delivery. The *conventional PM practice* is based on a multiparty and multi-contract phased approach to project delivery. Much of the information used is created and managed manually and through group coordination meetings. The project manager sees his or her role in coordination of these inputs, rather than presiding over the entire process, giving it purpose, direction, and focus in direct relation to the project life-cycle objectives (Jaafari 1997, Jaafari & Manivong 1998).

Breakdown in communication is a common problem on many projects. Design and specification errors discovered during construction typically cause delays and extra expenditure (Jaafari & Manivong 1998). Implementation of stakeholder-initiated changes tends to create complexity more due to a lack of a commonly agreed on model of the project for communication and integration purposes than any other factor. In terms of creating synergy, often there is no single point of control over the flow and destination of information or management of the entire communication process (Abdalla 1991). Therefore Itol (1991) suggested the creation of a central databank, which can be used to implement a product or project model where project information can be accessed and integrated by all project participants.

In essence, there are two reasons for the conventional practice of information and communication management to cause suboptimal project results, namely, (1) lack of a commonly agreed-on model of the project to act as a vehicle for effective communication and integration of the work of the various participants and (2) absence of integration of the information across the entire project life cycle, particularly with respect to constituent products or deliverables, whose realisation depends on the effective integration of information provided by designers, suppliers, constructors, regulatory authorities, users, and/or owner of the facility (Jaafari & Manivong 2000).

2.2.2.2 Alliance approach

The *alliance method* of project delivery proclaims a new culture in the way team members work together. Often the culture moves away from finger pointing and/or finding the party at fault. Contractual interfaces are minimised via the single alliance contract that binds all the parties in the alliance to be individually and jointly responsible for the outcomes of decisions made or plans implemented by the alliance. Current tools and techniques of PM have not made it possible for PM functions to be integrated and evaluated holistically even though the project environment might be well suited to integration. Jaafari and Manivong (2000) argue that it is essential to collect information on soft areas systematically and evaluate these in real time using *lifecycle objective functions (LCOFs)* as the basis for optimisation.

The integration of teams within a more collaborative (and less fragmented) environment has numerous benefits in project development. Anumba et al. (1997) have stated that alliance projects entail some aspects of concurrent engineering. As expressed by Thomson (1997) openness and cooperation between parties are encouraged by the alliance establishment. Notwithstanding the value of alliance structures, the current tendency has not been to systematically integrate information by the parties in the alliance throughout the project life. One major aspect that may militate against information integration is the use of functional project organisation structures, with responsibilities generally allocated along the discipline lines. A better model for information integration is to use a fully integrated multidiscipline team structure and attempt to unify the entire information sets used for significant decisions or plans for the project under consideration (Jaafari & Manivong 2000).

2.2.2.3 Life Cycle Project Management (LCPM) approach

The *Life Cycle Project Management (LCPM)* approach is not intended to control discipline-specific modelling or manage the information that different disciplines typically generate in order to produce their discipline-specific solutions for the project. However, it requires that the end solutions from all the relevant disciplines be expressed in terms of products and parts, as agreed to by teams and in a manner understood by the project manager and other parties. The flow of communication to and from the LCPM project model will be continuous throughout the currency of the project. In this context information on operability, environmental protection, occupational health and safety, quality, stakeholders' interest, and so on is of a qualitative nature and must be evaluated using a reflective practice approach (Jaafari & Manivong 1998). A protocol set up for each project at the outset will facilitate the communication and integration of team inputs into the project model.

The choice of the breakdown structure is critical because division into small parts (or products) may be too cumbersome and will result in information overload; conversely, division into large parts will not give adequate control over the formation and optimisation of the project (Jaafari & Manivong 1998). The project model is based on establishing a protocol for each project at the outset so as to facilitate proper definition and generation of information on project parts, components, products, and deliverables. Given the state of the art in product definition, it is not possible to achieve the information integration accurately unless an appropriate protocol is established up front.

Having described these different perspectives toward project management the next section will now analyse and contrast the approaches from information and communication point of view.

2.2.2.4 Differences in team communication and management

Referring to Jaafari and Manivong (2000) in the *alliance approach*, a single project organisation is formed from the parties in the alliance to deliver the project. An alliance board whose members are from the parties in the alliance, each with equal vote, oversees the operation of the alliance organisation. The culture in the alliance promotes teamwork, where all participants are constantly encouraged to see the alliance as the main organisation and thus pool together their combined intellect, resources, and knowledge to produce results. A less than optimal contribution from an alliance member may affect the performance of the whole alliance. A major distinguishing feature between the *alliance* and the *LCPM approaches* is that in the latter, multi-disciplined teams are formed for each major part or system of the project. Each team is required to deliver its part from concept through completion and interact with other teams. Thus the focus is considerably more sharpened on tracking the parts within the team environment, as opposed to focusing on work packages as in the case of a functional/matrix structure.

In addition, the entire project is planned as a single phase integrated design-construct-start-up undertaking, thus removing the problems and inefficiencies often associated with phased-delivery approaches. It has to be noticed that the status of the project is monitored not so much as the relative portion completed of the entire project in each phase but as the status of parts over the entire development cycle. However, the same cannot be observed on *alliance* and *conventional approaches*. Moreover, when it is desired to use concurrency (virtually in all situations to shorten the delivery time scale), it is necessary to schedule, coordinate, and integrate all the inputs forwarded by the teams in real time. A dynamic scheduling capability is thus required that is currently available as part of the life cycle PM model only. The communication system must be totally integrated so that conflicts can be resolved and to ensure that information and decisions are shared among teams.

Summing up this section, the conventional PM practices have evolved over many years in order to accommodate the customary phased approach to project management. The emphasis in these practices has tended to be on achieving the traditional objectives of time, cost, and quality, whereas the main emphasis in the alliance and LCPM models is on the achievement of team/information integration and thus delivery of a viable business to the owner (Jaafari & Manivong 2000). The subsequent part will now describe and discuss projects as knowledge-driven environments.

2.2.3 Projects as a context of knowledge utilisation

The discourse of knowledge management is increasingly evident within the project management literature (e.g. Fernie et al. 2003). Considering project teams as ‘knowledge workers’ the issue of how better to share knowledge across teams and between knowledge workers becomes of central concern to project managers. The issue of knowledge sharing also becomes increasingly important to many project-based organisations as they turn themselves into service companies that are increasingly divorced from the physical work of production.

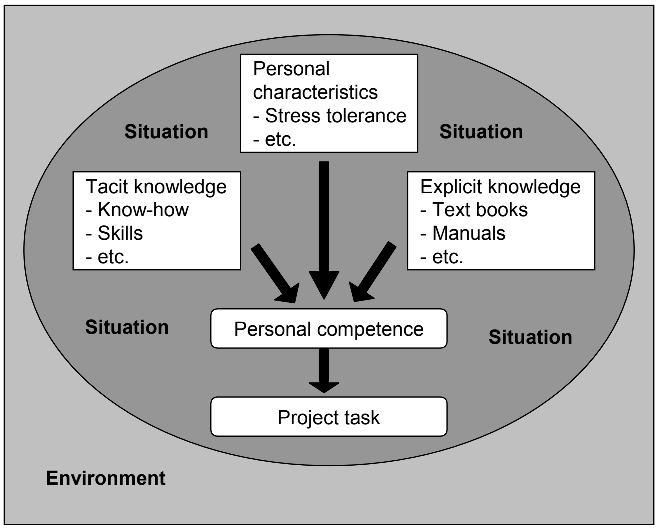
The epistemological orientation of the project management discipline tends towards a functionalist, managerialist framework of knowledge that readily accepts the link between knowledge and competitive advantage perceived elsewhere (Lanzara &

Patriotta 2001). The authors criticise this orientation for its lack of scrutiny on knowledge per se and its tendency to conceptualisation knowledge as an objective, transferable commodity. Much effort has also been expended on the codification of project management into 'bodies of knowledge' (PMI 2000). The underlying assumption is that such bodies of knowledge retain any meaning once divorced from context (Fernie et al. 2003). Most project managers would readily admit that there is little substitute for experience, thereby implying that knowledge derived from experience cannot easily be codified.

Given the knowledge intensive character of projects Koskinen et al. (2003) introduce competence as another important prerequisite for individuals to perform a task. Von Krogh and Roos (1996, p. 106) point out that "…knowledge is about specific insights regarding a particular topic, competence is about the skill to carry out work". Referring to Figure 2-3 the competence of an individual member of a project team can be divided into three sections:

> *Explicit knowledge*, which is the type of knowledge that an individual has acquired mainly in school and university. Explicit knowledge implies factual statements about such matters as material properties, technical information, and tool characteristics. Thus, explicit knowledge can be expressed in words and numbers, and is therefore easily communicated and shared.
>
> *Tacit knowledge*, which is highly personal and hard to communicate or to share with others. Tacit knowledge is deeply rooted in an individual's experience and it consists of schemata, belief, and perceptions stored so deep in the worldview of an individual that we take them for granted.
>
> *Personal characteristics* such as stress tolerance, which either enhance or decrease an individual's ability to perform a task, and which are also a part of individual's competence.

Figure 2-3: The structure and development of personal competence



Source: Koskinen (2001)

Based on this distinction Koskinen et al. (2003) provide a classification model by which projects can be categorised into different categories in accordance with the need to use explicit and tacit knowledge in them. The first category consists of *research-, development-, and design projects* where goals are not always clear at the outset of the work. Also the means and procedures needed in the course of the project implementation are often unclear. This means that at the outset of the project the possibilities to foresee the future results and success of the project are rather poor. Thus, one can conclude that abundant use of tacit knowledge is often necessity in these types of projects. The second category includes *delivery- and investment projects* where goals are often clear at the outset of the work. Also the means and methods needed in the implementation of the project are usually well known. This means that the possibilities to foresee the results of the project at the beginning of the project are good. Thus, one can conclude that the possibilities to use mainly explicit knowledge in these types of projects are good.

Ideally a project would have much explicit knowledge and little tacit knowledge about the activities to be implemented (Koskinen 2001). However, in practice a project team is likely to know only a little about some important issues. For example, knowledge about customer needs is often unclear at the outset of a product development project. Conversely, the project team may have a lot of explicit knowledge about some unimportant tasks (Koskinen et al. 2003). Indeed, a project can be seen as a knowledge intensive task, which can be approached in terms of the quality and quantity of the knowledge. Therefore the next section concentrates on general as well as project-related knowledge models and corresponding knowledge roles and skills. All presented sources share a more or less Newtonian and rational perspective. At a later stage of this literature review a more socio-cultural and sense-making approach will be presented and discussed (see chapter 2.4).

2.3 Knowledge – A valuable resource and complex process

Drucker (1995, p. 271) writes that “knowledge has become the key economic resource and the dominant – and perhaps even the only – source of competitive advantage”. This follows his assertion that increasing knowledge-work productivity represents the great management task of the century, comparable with the innovation and productivity improvement made through industrialisation of manual-work processes. But Miles et al. (1998, p. 281) warns that “Knowledge, despite its increasing abundance, may elude managerial approaches created in the 20th century mindsets and methods”. And, indeed, knowledge is proving difficult to manage, and knowledge work has been stubbornly resistant to reengineering and process innovation (Davenport 1995).

Snider and Nissen (2003) emphasise that most of the actual literature on knowledge management characterises knowledge as flowing according to one of the following three perspectives:

> *Knowledge as Experience* – In this perspective, knowledge is recorded and stored for future use. The focus is on capturing practitioner experiences so that others may have access to and may potentially learn from them. The principal flow of knowledge is across time, rather than across organisational or geographical space. Referring to Snider and Nissen (2003) examples of such KM efforts include organisational histories, lesson-learned systems (Aha 2000; Snider, Barret & Tenkasi 2002), “Best-practices” guides (Snider & Walkner 2001), after-action reviews (Busby 1999), and other organisational learning mechanisms (Lipshitz, Popper & Oz 1996).

> *Knowledge as Solution* – This view stresses the often real-time transfer of knowledge among practitioners seeking to solve problems or enhance operations. KM efforts focus on technologies and processes, which enable linkages and facilitate communications among members of the organisation. According to Snider and Nissen (2003) several case studies, for example

Davenport (1997), Orlikowski (1993) and Fulmer (1999), illustrate this perspective and its associated issues.

Knowledge as socially created – In contrast to the two previous perspectives which characterise knowledge as a commodity that may be transferred to others, this view portrays knowledge as socially created or as the product of interpersonal relationships (Berger & Luckman 1967 as cited in Snider & Nissen 2003). Managerial issues associated with this perspective are substantially different from those other two approaches. Here the major issue is organisational design to enhance development of interpersonal relationships. Members must engage in informal, unstructured communications and processes of sense making (Weick 1979), where discussion, negotiation and argument are central to the learning process. Referring to Brown and Duguid (1991), "communities of practice" arise along informal organisational lines and their development and effectiveness actually may be inhibited by managerial efforts to institutionalise them.

After this short review of different knowledge-flow perspectives, the following part will now introduce and contrast major knowledge management approaches and models in more detail.

2.3.1 Principal Knowledge Management Life Cycles

As already argued in the previous section, one can observe a sense of process flow or a life cycle associated with the practice. Despite the multitude of models now discussed in the literature, they all share similar elements and properties. Table 2-2 compares a sample of dominant knowledge management life cycles proposed by several researchers and consultants.

Most of these models begin with a "Create" or "Generate" phase; Nissen (1999) and Jordan and Jones (1997) use the term "Acquisition" and "Capture". The second phase deals with the organisation, mapping or bundling of knowledge; Davenport and Prusak (1998) omit this organisation phase, but it appears very prominently in most of the others. Phase three uses different expressions across the models, but they all address some mechanisms for making knowledge formal or explicit. Although Nonaka and Takeuchi's (1995) model actually contains five phases the aspects "Justification of Concepts" and "Building an archetype" have been combined to fit into the chosen framework. Phase four, just as the previous one, uses different terms but describes the ability to share or distribute knowledge in an organisation. Four of the six models include a fifth phase for application or (re)use of knowledge. Demerst (1997) as well as Jordan and Jones (1997) introduced a sixth phase in which the constructed knowledge is embodied or stored within an organisation. The aspect of “Evolving” used by Despres and Chauvel (1999a) pictures the iterative and recurring character of the knowledge workflow. Boisot (1998) proposes a different model grounded on an information perspective and complexity science. According to the author knowledge assets emerge as a result of a two-step process, constituting the two distinct phases of the evolutionary production function: creating knowledge and applying knowledge. Next, key issues regarding the mentioned models will be briefly described and discussed (see Table 2-2).

Table 2-2: Principal Knowledge Management Life Cycle Models

Model	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Nissen (1999)	Capture	Organise	Formalise	Distribute	Apply	
Despres & Chauvel (1999a)	Create	Map/Bundle	Store	Share/Transfer	Reuse	Evolve
Davenport & Prusak (1998)	Generate		Codify	Transfer		
Demerest (1997)	Construction			Dissemination	Use	Embodiment
Jordan & Jones (1997)	Acquisition	Problem solving		Dissemination	Ownership	Storage
Nonaka & Takeuchi (1995)	Sharing tacit Knowledge	Creating Concepts	Justify Concepts & Building archetype	Cross-levelling Knowledge		
McElroy (2002)	Knowledge Production			Knowledge Integration		
Boisot (1998)	Knowledge creation				Knowledge application	

Source: Developed from Nissen et al. (2000a, p. 224); Nonaka & Takeuchi (1995); Ortiz et al. (2003) and Bredillet (2004)

McElroy (2002), acting with other members of the Knowledge Management Consortium International, has defined a framework of Knowledge Management called “The knowledge life cycle”. This model has an important consideration, because in addition to the proposal of Nonaka and Takeuchi (1995), it assumes that knowledge exits only after it has been produced, and after this it can be captured, codified and shared. Consequently, the McElroy model is divided in two major processes, Knowledge Production and Knowledge Integration (Ortiz et al. 2003):

Knowledge Production is the process were new organisational knowledge is created. This is formed by individual group learning, knowledge claim, information acquisition, codified knowledge claim, and knowledge claim evaluation. This process is synonymous with “organisational learning”.

Knowledge Integration is formed by some activities that allow knowledge sharing and distribution. It includes knowledge broad-casting, searching, teaching, sharing and other social activities that communicate.

The McElroy model, introduces two new concepts, Demand Side and Supply Side (Ortiz et al. 2003; McElroy 2002). *Supply-side* is the practice of Knowledge Management in any way that is designed to enhance the supply of existing knowledge to workers in an organisation. *Demand-side* focuses on the supply of existing knowledge to a workforce and it seeks to enhance their capacity to produce. The mission of demand-side Knowledge Management, then, is to enhance an organisation’s capacity to satisfy its demand for new knowledge. The important assumption is the impact on an organisation’s capacity to produce and integrate knowledge by making a range developing of interventions aimed at supporting, strengthening, and reinforcing related patterns of behaviour (McElroy 2002).

Models of knowledge management which emphasise the social construction of knowledge share common ground with work on learning organisations and organisational learning. Demerest's (1997) model is one example of such a model. He identifies four phases of knowledge management within an organisation: knowledge construction, knowledge dissemination, knowledge use and knowledge embodiment. The model emphasises the construction of knowledge within an organisation, with both scientific and social contributions to this construction process. According to the model, constructed knowledge is then embodied within an organisation, both through explicit programs, but also through social interchange. Following embodiment there is a process of dissemination of the espoused knowledge throughout the organisation and its environments. There is also a recognition that the process moves back and forth between the different phases. The model is similar to that proposed by Jordan and Jones (1997), who identify the phases of knowledge acquisition, problem solving, dissemination, ownership and storage.

Nonaka (1988) has arguably been one of the most influential proponents of the knowledge creating organisation; he recognised the concept of top-down or deductive management and bottom-up or inductive management, both concerned with an organisation's capacity to process information. However, information processing needs to be coupled with knowledge creation. Nonaka's (1991) concept of a knowledge creating company is concerned with making individual insight available for testing and use by the company as a whole. Knowledge creating companies constantly encourage the process whereby personal knowledge is made available to others (articulation) for them to use to extend their own tacit knowledge base (internalisation).

The role of management is to provide a conceptual framework that helps employees to make sense of information. Nonaka's (1991) primary concern is with the knowledge creation associated with internalisation and articulation. Later, in context with their theory of organisational knowledge creation, Nonaka and Takeuchi (1995, p. 56) postulated four modes of knowledge conversion based on the assumption that knowledge is created through the interaction between tacit and explicit knowledge. The four modes, socialisation, externalisation, combination and internalisation were conceptualised in their epistemological and ontological dimensions to demonstrate a spiral process of organisational knowledge creation (see Appendix A).

The s*ocialisation* process aims at getting key actors to share personal or tacit knowledge. At this stage the knowledge is still primarily the personal possession of employees or key actors or the collective possession of teams (Erwee et al. 2000). *Externalisation* creates new, explicit concepts from tacit knowledge. If key actors share this knowledge with other team members or peers through metaphors or analogy, such metaphors can create a common 'network of new concepts' (Nonaka & Takeuchi 1995, p. 67). In global project teams operating in countries with a variety of languages, cultures and business practices, the creation of common metaphors may be part of the challenge.

Combination involves integrating different bodies of explicit knowledge. In many cases this happens if key actors exchange information through documents, meetings, telephone conversations, e-mail or Intranet discussion groups. If the information is sorted, categorised or combined by manual or computerised methods, further discussion of this explicit knowledge can lead to the creation of new knowledge. Externalising such codified knowledge allows it to be transmitted rapidly and to larger audiences whereas tacit knowledge is initially shared slowly in face-to-face situations under conditions of trust. Enterprises differ in the kinds of knowledge development systems that they adopt. Some firms adopt a ‘theorising and codifying’ form of learning bias, whereas others develop learning-by-doing systems that lead to ‘tangible knowledge integration’ (Sanchez & Heene 1997, p.11 as cited in Erwee et al. 2000). Finally, the *Internalisation* of explicit or new knowledge by key actors make it part of their own expanded repertoire of tacit knowledge.

However, Fong (2003) identified some limitations in Nonaka and Takeuchi’s (1995) knowledge creation model that lessen its suitability for the study of knowledge creation in multidisciplinary project teams. Their primary distinction between tacit and explicit knowledge is problematic, as tacit or unarticulated knowledge is always a precondition for explicit knowledge (Polyani 1962). Tuomi (1999 as cited in Fong 2003) also criticises the model for taking culture and language for granted. The difficulty of discussing the role of language as a ‘repository of culturally shared meaning’ (p. 340), critical for any knowledge creation theory, may make its use difficult for multidisciplinary project teams. It is also not clear what happens when the knowledge-creating spiral expands outside a team: is knowledge still created in the same way? Furthermore, Fong (2003) states that though Nonaka and Takeuchi (1995) stress that the process of knowledge creation is ‘social’, their underlying focus is on individual and intra-personal knowledge.

Boisot (1998) defines an Information space (I-Space) according to three dimensions: codification, abstraction and diffusion. The creation and diffusion of new knowledge occurs in a particular sequence: scanning, problem-solving, abstraction, diffusion, absorption, impacting. Referring the identification of two distinct strategic orientations for dealing with the paradox of value (i.e. "maximising the utility of knowledge assets compromises their scarcity, and maximising their scarcity make it difficult to develop and exploit their utility", p. 90) Boisot (1998) introduced two individual, but not mutual exclusive, forms of learning. In neoclassical learning (*N-Learning*) knowledge is considered cumulative and learning becomes a stabilising process. This approach may lead to excessive inertia and fossilisation of the knowledge assets. In Schumpeterian learning (*S-Learning*), change is the natural order of things. Abstraction and codification are incomplete. S-Learning is more complex than N-Learning integrating both certainties and uncertainties, and requires an "edge of chaos" culture (p. 116).

Thus, in essence, the majority of the depicted models share similar elements and properties and follow a process flow or a life cycle approach. The missing theoretical and, even more important, practical evidence regarding the application of the described approaches in dynamic and often complex situations associated with virtual project settings questions their suitability. Referring to the special focus of this dissertation on knowledge management in project teams the following section will address relevant perspectives and process models in more detail.

2.3.2 Project-related knowledge perspective and processes

To understand the specificity created by the project environment and project team focusing in knowledge management and learning in general relevant perspectives and characteristics will be introduced first. The concept of 'learning organisation' has actually been derived from the psychological concept of 'individual learning' (Weick 1991). Almost all definitions of organisational learning are based on this analogy (Bredillet 2004). Research on learning organisations principally gained momentum with the publication of The Fifth Discipline by Peter Senge (1990) as well as studies by Brown and Duguid (1991).

Having in mind the need for efficiency and effectiveness, a project team acts as a temporary structure, generating first information and creating knowledge (adding complexity) with many degrees of freedom, and then applying it (reduction of complexity) in the later stage of a project (Bredillet 2004). According to the author the consequence at the knowledge management level is twofold (see Table 2-3). On the one hand, focusing on the 'Have' side, there is a need for knowledge at the individual, team and organisational level e.g. guidance, best practice, standards, etc. Such standards have to be seen as largely social constructs, developed to facilitate communication and trust among those who are adopting them, but their constant evolution in line with the experiences gained by the users or because of new developments or practices is vital to avoid any fossilisation (Bredillet 2002). On the other hand, on the 'Be' side, the need of more creative competence, flexible frameworks, and supportive organisational surroundings to enable the sharing of experience is fundamental. After having addressed these different perspectives focusing on operations vs. project-related characteristics, relevant knowledge processes and its management will be presented and discussed next.

Table 2-3: Synthesis of two perspectives regarding Knowledge Management, Organisational Learning and Learning Organisations

Main acting mode	**[Organisational] Operations**	**Projects**
Epistemology	**Positivist – 'Have'**	**Constructivist – 'Be'**
Knowledge Management	• Western approach • Codification • Explicit knowledge • Linear thinking • Knowledge market	• "Japanese" approach • Personalisation • Tacit knowledge • Dialectical thinking: "synthesising dialectical thinking", aiming at identifying contradiction and resolving it by means of synthesis or integration
Organisational Learning	• Single loop learning • Information theory (knowledge as formal and systematic-hard data, codified procedures, universal principles)	• Double loop learning • Information theory (Nonaka 1991, Boisot 1998) • System dynamics theory (Senge 1990, Kim 1993)
Learning Organisation	• Neoclassical learning (N-Learning), knowledge is considered cumulative (Boisot 1998)	• SECI cycle, Knowledge assets, needs for a supportive organisation (Nonaka 1991) • Schumpeterian learning (S-Learning), change is the natural order of things (Boisot 1998)

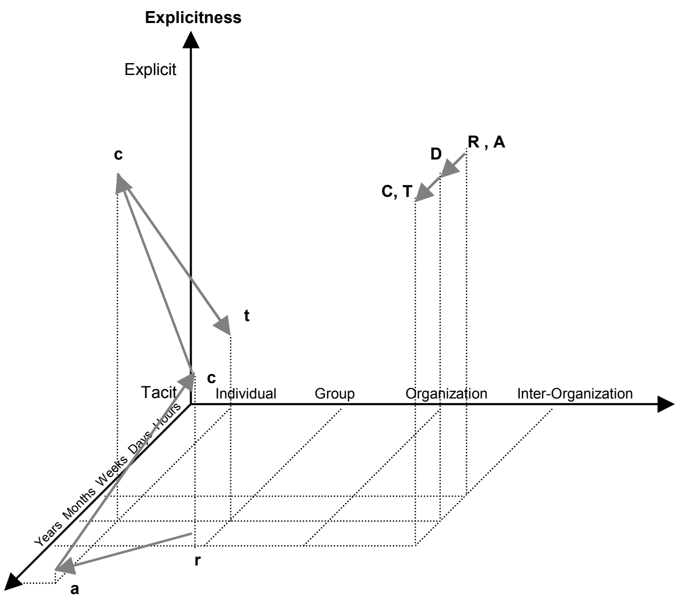
Source: Bredillet (2004)

To build a sufficient theoretical foundation two prevalent approaches, one by Snider and Nissen (2003) and the other by Fong (2003) will be elaborated. Building upon prior research by Nissen (2002), the flow of work and the flow of knowledge in an organisation are highly interrelated. Referring to Oxendine and Nissen (2001) the flow of work is described as horizontal processes whereas the flow of knowledge is specified as vertical processes. Based on the work of Nonaka (1994) and Nissen (2002), Snider and Nissen (2003) developed a model of knowledge flow with four dimensions: explicitness, reach, life cycle and flow time, which will be now discussed in more detail.

The dimension of *explicitness* is characterised as a continuum with explicit and tacit knowledge as extremes. It depicts the degree to which knowledge in some areas can be articulated. The *reach* dimension describes the extent to which knowledge is shared with others in a given setting, e.g. individual, work group, organisation, inter-organisation. The *life-cycle* dimension derives from Nissen, Kamel and Sengupta (2000b as cited in Snider & Nissen 2003) and portrays the flow of knowledge though six discrete phases at it is managed in work setting: creation, organisation, formalisation, distribution, application and evolution. At last, because of the inherent dynamic character of knowledge flows, the dimension of *flow time* depicts the length of time required for a particular chunk of knowledge to complete the flow through an organisational environment. Finding by Nissen (2001) implies that this flow time can vary by several orders of magnitude in modern organisations, e.g. hours, days, months or years.

Using a software development project for illustration Snider and Nissen (2003) delineate two distinct knowledge flows that both enable and interrelate with the complementary flow of work associated with the final product (see Figure 2-4). The first flow, labelled R-A-D-C-T, in the figure, depicts knowledge flowing in the highly explicit form associated with formal documents.[1] Such explicit knowledge results as a direct product of the work flow. Referring to the terminology introduced, explicit knowledge is linked to the software documentation is formalised through the *horizontal process* corresponding to software development. The second flow, labelled r-a-d-c-t in the figure, acquired through *vertical processes* like education, training and work experience.

Figure 2-4: Project Management Knowledge Flows



Source: Snider & Nissen (2003)

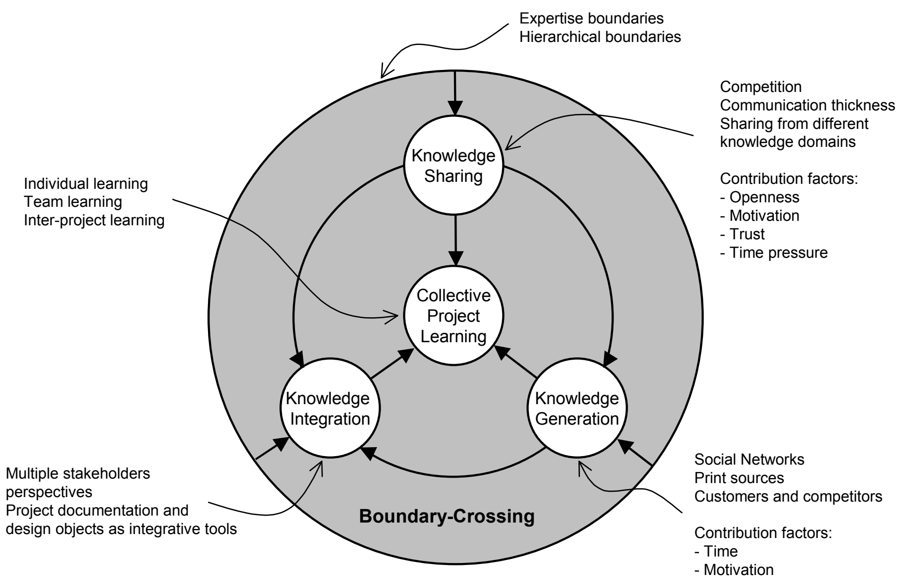
Thus, in the case of explicit knowledge associated with formal project documents the flow is simple, linear and restricted to a single level of in terms of the dimensions of

[1] The flow pictures linear development through five sequential phases: (R)equirements, (A)rchitectual design, Software (D)esign, (C)oding and (T)est.

reach and explicitness. Snider and Nissen (2003, p. 10) point out that "…formal knowledge such as documentation *results* from the work, whereas the (more) tacit knowledge flows associated with the vertical process *enable* the work to be accomplished in the first place". In summary, the authors argue that a dynamic perspective of knowledge like the discussed four-dimensional knowledge flows provides a more complete and integrative framing of project-related knowledge management. It has to be mentioned that this fluid view of knowledge is, however, at odds with the more static view implied in extant project focused bodies of knowledge, e.g. the PMBOK (PMI 2000).

The next approach differs from the one presented by Snider and Nissen (2003), because it is not based on the organisational knowledge creating theory introduced by Nonaka (1994) or respectively by Nonaka and Takeuchi (1995). Based on an explorative case study in the construction and real estate sector Fong (2003) developed a process model targeting knowledge creation in multidisciplinary project teams, whose five processes will be presented and discussed next. According to the author the overall procedure starts with the pre-requisite boundary-crossing process, which then leads to the three knowledge processes of knowledge-sharing, knowledge generation and knowledge integration (see Figure 2-5)

Figure 2-5: Interrelationships between multidisciplinary knowledge creation processes



Source: Fong (2003)

The first process in knowledge creation involves *boundary crossing*, with two types of boundary identified as affecting the progress and success of multi-disciplinary knowledge creation. The first boundary identified was between team members of different disciplines. The second boundary existed between client, consultant and contractor. The importance of boundary crossing is reflected in solving the boundary paradox' (Quintas et al. 1997), where team members are able to exchange and combine knowledge (Nahapiet & Ghoshal 1998). It must be stressed that crossing boundaries does not necessarily guarantee the creation of knowledge (Fong 2003). It is seen, however, as a pre-requisite for the four remaining processes to occur.

The second process relates to *knowledge-sharing*, with project team members of differing knowledge domains more likely to discuss their uniquely distinct information and knowledge than those who possess information in common. Despite the existence of little competition among team members, external competition could act as a double-edged sword in the knowledge-sharing process (Fong 2003). Sharing important market or design knowledge could lead to imitation by competitors, possibly even resulting in project poaching. In addition, the author stresses the importance of interpersonal communication to allow tacit knowledge to be effectively transmitted.

The third process to be considered is that of *knowledge generation*; in which teams create knowledge by generating new or 'emergent' knowledge through interaction and communication. New or emergent knowledge, not possessed before discussion, can develop through group discussion and interaction (Quintas et al. 1997). The development of emergent knowledge is vital for creativity and innovation. It is generated through various means, including those of social networks, printed sources, and customer and competitor feedback. Social networks were identified as the most important vehicle for information and knowledge exchange, with team members heavily reliant upon colleagues, friends and ex-colleagues as rich resources for generating design knowledge.

Fourth is *knowledge integration*, realised by marrying the differing perspectives and knowledge of various disciplines in the overall decision-making process. It enables different stakeholder views to be incorporated so that they can be considered and integrated. Various team members brought different sets of assumptions about optimal ways to proceed, prioritising different values and perspectives to ultimately best meet stakeholder requirements as well as arrive at satisfactory design solutions. Project documentation, as well as various design objects, was used as tools to integrate the range of knowledge input from project participants.

Collective project learning is central to the last three knowledge processes. Fong (2003) emphasises that these knowledge creation processes within multidisciplinary teams are not linear. Instead they are interwoven, occurring throughout projects. Through these interwoven processes, new or emergent knowledge is created within the project team, or existing knowledge is combined to form new insights. Problem-solving being central to their work, team members also recognised that failure was an opportunity for learning and understanding (Fong 2003). Understanding failure is a primary mechanism in learning how new technology and systems operate, optimally avoiding repetitive mistakes. The author stresses that considerable effort should be made to support an individual's critical problem-solving and reflection processes. Individuals then develop personal strategies based on their own thinking and learning preferences.

Summing up this approach developed by Fong (2003), it was found that the project teams needed to cross boundaries imposed both by the range of diverse professional disciplines and also by the hierarchical divisions of client, consultant and contractor before genuine work, problem-solving or pertinent knowledge creation could occur. Without boundary-crossing, team members could focus simply on their own disciplinary work without due regard for or collaboration with other disciplines. Following this discussion of project-related knowledge approaches the next section will address common knowledge roles and skills and put them into context with already presented knowledge models and aspects.

2.3.3 Knowledge Roles and Skills

Nonaka (1994) describes knowledge worker as mostly professional, well-educated and relatively autonomous, often with substantial responsibilities in the organisation. They tend to seek and value their relative autonomy and often resist perceived interference by management in knowledge-work activities (Davenport et al. 1996). This part builds on Erwee et al. (2000), who described key actors and their roles in the context of knowledge management in multinational companies. The primary focus will be on those individuals involved in the creation of knowledge or the 'knowledge creation crew' (Nonaka & Takeuchi 1995, p.152), namely knowledge practitioners. Referring to the actual area of research – virtual project teams - Davenport and Prusak's (1998) argument that knowledge management will not succeed if it is solely the responsibility of a small specialist group, is of minor relevance at that point.

Knowledge practitioners within multinational companies can be divided into two complementary groups, knowledge operators and knowledge specialists. The knowledge operators accumulate or generate tacit knowledge by being exposed to operating conditions of the firm and through action learning experiences. Specialists generate or analyse well-structured explicit knowledge usually in the form of scientific or other technical data. Both groups usually have high intellectual standards, have a wide variety of experiences within and outside the firm and are able to dialogue with customers as well as colleagues (Nonaka & Takeuchi 1995, p.154). In analogy with Davenport and Prusak (1998) practitioners within project environments may act as boundary spanning knowledge buyers who are searching for knowledge to solve a complex issue and want to acquire insights, judgements or understanding that another key actor possesses.

Knowledge engineers serve as a bridge between visionary ideals of leaders and the realities faced by knowledge practitioners. Nonaka and Takeuchi (1995, p.154) characterise this group as able to "remake reality or engineer new knowledge according to the company's vision" and are most often found at middle management level in dispersed companies. They are able to synthesise the tacit knowledge of both practitioners and senior executives, make it explicit and incorporate the knowledge into new products, services or systems. This implies that they not only need to be able to engender trust among network members but also that they should be able to envision a future course that members can identify with. The knowledge engineers are usually skilled in project management, can formulate hypotheses or metaphors to create new concepts, and need to have the ability to "integrate different methodologies to create knowledge" (Ibid, p. 156). Skilled knowledge engineers in a boundary spanning network may become knowledge sellers if they have a reputation of substantial knowledge about a process or subject, are able to articulate the tacit knowledge and willing to share the information or insights (Davenport & Prusak 1998).

Knowledge officers within organisations manage the overall knowledge-creation process at the corporate level by articulating the company vision, "establishing a knowledge vision" and setting the standards for "justifying the value of the knowledge that is being created" (Nonaka & Takeuchi 1995, p.156). This group of people usually has the ability to select project managers and have a capability to “create chaos in the project team by setting inordinately challenging goals” (Nonaka & Takeuchi 1995, p. 158). Although the latter perspective focuses on their roles within an organisation it could be applicable between members in the firm’s boundary spanning networks.

The concept of *Knowledge Integrator Nodes* (KIN’s) which was developed by Erwee and Brown (2000) adds another dimension which extends the knowledge-creation process of the described models and particularly that of Nonaka and Takeuchi (1995). The concept concentrates more on the way in which “knowledge is managed in order to ensure the creation and extraction of value to the organisation in the knowledge creation process” (Erwee & Brown 2000, p. 13). KIN’s are individuals who deliberately integrate explicit knowledge gained from peers in knowledge creation crews and then disseminate it across organisational boundaries. As Poh (2000) further elaborates, the concept of the KIN means that: “The creation of knowledge is no longer the activity of an organisation (network component) working in isolation, but the collaborative result of its members working closely in internal groups and in partnership with other organisations.” This statement encapsulates the concept of ‘boundary-spanning’ by knowledge nodes because it includes and emphasises the way in which they take knowledge gained from working with intra firm knowledge creation crews and progress this knowledge both within the organisation and its peripheral stakeholders but also progressively upwards within the organisation to more senior management levels as potential inputs into corporate policy decisions.

Giving the imminent notion that in an increasingly uncertain and complex business environment new models have to be found to enhance and/or substitute the rational, Newtonian perspective to knowledge management the next chapter will present and discuss such a more cultural-focused and sense making approach.

2.4 The socio-cultural side of Knowledge Management

Culture does play an important role in the success of a knowledge management effort. Companies that successfully implement knowledge management do not try to change their culture to fit their knowledge management approach. They build their knowledge management approach to fit their culture (McDermott & O’Dell 2001). Most of these organisations are laced with informal social networks that people use to find ‘who knows what’, get help and advice, learn how to use specialised tools, etc. Their members trust each other and feel obliged to share information and insights with each other. Through these informal networks, individuals get appreciation from their peers and oftentimes form strong personal relationships (McDermott 1999).

2.4.1 The Cynefin framework

The Cynefin[2] model by Snowden (2001) focuses on the location of knowledge in an organisation using cultural and sense making aspects of four different forms of community, both formal and informal. Allowing self-organisation of knowledge within an organisation, utilising but not being used by the informal or shadow organisation is seen as key to effective knowledge management. The author distinguishes between mechanical, Newtonian models of management science and a new organic approach, which draws on concepts from complexity theory. This perspective differs from the Japanese concept of Ba, which is a “shared space for emerging relationships” (Nonaka & Konno 1998) in that it links a community into its shared history – or histories – in a way that paradoxically both limits the perception of that community while enabling an instinctive and intuitive ability to adapt to conditions of profound uncertainty (Snowden 2001).

The author points out that it has to be recognised that human society is diverse and multi-dimensional. People can and do resist mandated behaviour. Ambiguity provides scope for individual interpretation and more rapid adaptation to change; the neat and tidy structures required by traditional IT systems design oversimplify complexity in order to achieve deliverables and consequently fail to reflect the richness of human space. Paradox allows humans (but not computers) to work with apparent contradiction, and in consequence create new meaning. This is of major importance for the developing discipline of knowledge management. A shift to thinking of employees as volunteers requires a radical rethink of reward structures, organisational form and management attitude. It requires us to think of the organisation as a complex ecology in which the number of causal factors renders pseudo-rational prescriptive models redundant at best and poisonous at worst (Snowden 2002).

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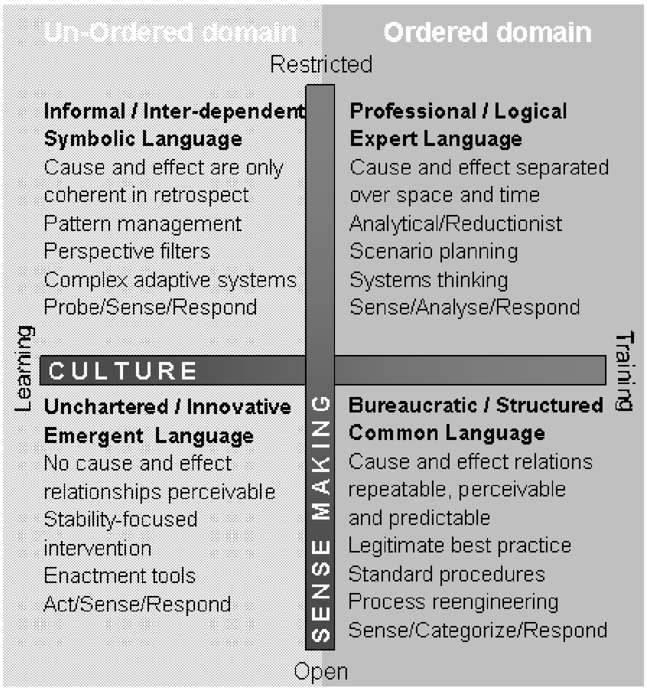
[2] Cynefin (pronounced cun-ev-in) is a Welsh word with no direct equivalent in English. As a noun it is translated as habitat, as an adjective acquainted or familiar.

The Cynefin model as depicted in Figure 2-6 is designed to create a holistic understanding of the different types of [knowledge] communities and community interactions within a social environment. The inherent sense making perspective of the approach can be best described using four different quadrants, characterised by two primary conditions (ordered vs. un-ordered) and the degrees of 'sense-making' and 'culture' (Snowden 2001):

Figure 2-6: Cynefin model: cultural sense making



Source: Adapted from Snowden (1999); Snowden & Kurtz (2003)

Ordered domain - Bureaucratic/Structured (Common language): This quadrant represents the formal organisation with its company policies, recruitment procedures, financial controls, and internal marketing. This sector can be characterised as a training environment with a known, explicit and open language. In this sector, cause and effect relationships are generally linear, empirical in nature, and not open to dispute (Snowden & Kurtz 2003). Repeatability allows for predictive [efficiency focused] models to be created, and the objectivity is such that any reasonable person would accept the constraints of best practice. Single-point forecasting, field manuals and operational procedures are legitimate and effective practices in this domain. The prevalent decision model here is to sense incoming data, categorise that data, and then respond in accordance with predetermined practice. Structured techniques are not only desirable but mandatory in this space.

Ordered domain - Professional/Logical (Restricted expert language): The most commonly understood form of expert language is that of the professional: an individual who, through a defined training programme and associated job function, acquires an ability to use explicit specialist terminology (Snowden 2002). The expert language and the time and basic skill it takes to acquire that expert language create the barriers to entry and define the nature of the restriction. Although stable cause and effect relationships exist in this domain, they may not be fully known, or they may be known only by a limited group of people (Snowden 2002). Usually, relationships are separated over time and space in chains that are difficult to fully understand. The predominant methodology in this domain is to identify cause-effect relationships through the study of properties which appear to be associated with qualities. For social environments in which the patterns are relatively stable, this is both legitimate and desirable. The decision model here is to sense incoming data, analyse that data, and then respond in accordance with expert advice or interpretation of that analysis (Snowden & Kurtz 2003). Structured techniques are desirable, but assumptions must be open to examination and challenge.

Un-ordered domain - Informal/Interdependent (Restricted symbolic language): Informal communities are more rigidly restricted than professional ones. In these environments symbolic languages have the ability to transport a large amount of knowledge or information in a very succinct way. The problem is that such languages are difficult to comprehend and near impossible to use unless the team member or user grow up in the community of symbol users. This is the domain of complexity theory, which studies how patterns emerge through the interaction of many agents. There are cause and effect relationships between the agents, but both the number of agents and the number of relationships defy categorisation or analytic techniques. Emergent patterns can be perceived but not predicted. In this space, structured methods that seize upon such retrospectively coherent patterns and codify them into procedures will confront only new and different patterns for which they are ill prepared (Snowden & Kurtz 2003). Thus, relying on expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognise and act upon unexpected patterns. The methods, tools, and techniques of the previous two ordered domains do not work here. Narrative techniques are particularly powerful in this space (Snowden 2002).

Un-ordered domain - Uncharted/Innovative (Emergent language): This sector can be characterised by the absence of a common language and represents an ultimate learning environment. Faced with something new organisations have a problem; they will tend to look at the problem through the filters of the old thus keeping the old models and old language in place (Snowden 2002). In the three previous domains, there are visible relationships between cause and effect. In this chaotic domain there are no such perceivable relations, and the system is turbulent; the users do not have the response time to investigate change (Lorenz 1993). Applying best practice is probably what precipitated chaos in the first place; there is nothing to analyse; and waiting for patterns to emerge is a waste of time. The decision model in this space is to act, quickly and decisively, to reduce the turbulence; and then to sense immediately the reaction to that intervention so that project team members can respond accordingly. Chaos is also a space team members can enter into consciously, to open up new possibilities and to create the conditions for innovation (Snowden & Kurtz 2003).

In summary, the described approach and other models covering organic knowledge management advocate the notion that the mechanical metaphor of Newtonian physics fails when we move to the management of intellectual capital: it is fine for process, quality and other activity that is mechanical in nature, but it fails when the principle component or actor is organic. Given the contextual complexity associated with the management of people and knowledge the following sections will discuss the aspects of culture, abstraction levels, language and boundaries as important influencing factors.

2.4.2 Culture - Shared ideas, concepts and rules

Several authors, e.g. Boland et al. (2001), Floyd (1999), Gupta and Govindarajan (2000), Nonaka (1996), Snowden (2002) and Starbuck (1992) highlight the importance of suitable socio-cultural norms as one key feature of knowledge-intensive organisations and team environments. Culture reflects an organisation's existing knowledge-base and directly influences an individuals' willingness to engage in active knowledge management. In this context, Keesing and Strathern (1998) identified two very different ways in which the term culture is used:

1. The socio-cultural system or the pattern of residence and resource exploitation that can be observed directly, documented and measured in a fairly straightforward manner. The tools and other artefacts that we use to create communities, the virtual environment we create and the way we create,

distribute and utilise assets within the community. These are *teaching cultures* that are aware of the knowledge that needs to be transferred to the next generation and which create training programmes. They are characterised by their certainty or explicit knowability.

2. Culture as an "...ideational system. Cultures in this sense comprise systems of shared ideas, systems of concepts and rules and meanings that underlie and are expressed in the ways that humans live. Culture, so defined, refers to what humans learn, not what they do and make" (Keesing & Strathem 1998). This is also the way in which humans provide "standards for deciding what is, ... for deciding what can be,.... for deciding how one feels about it, ... for deciding what to do about it, and ... for deciding how to go about doing it." (Goodenough 1961 as cited in Keesing & Strathern 1998). Such cultures are tacit in nature: networked, tribal and fluid. They are *learning cultures* because they are deal with ambiguity and uncertainty originating in the environment, or self generated for innovative purposes.

Both definitions are key to the flow of knowledge within an organisation or a team. The mechanisms for learning are very different from those for teaching. In the case of teaching there is little ambiguity between teacher and taught, in learning such ambiguity is often a necessary precondition of innovation. The costs and scalability are also different, in the case of teaching the population of 'students' can be large, varying to some degree with the level of abstraction; reliability, scalability and economies of scale are both realistic and sensible. Learning is more about providing space and time for new meaning to emerge, research facilities are not cheap and not all employees can realistically be provided with space of learning, as opposed to the application of what can be taught (Snowden 2002). From the above discussion the following tentative proposition emerges:

> *Socio-cultural aspects are one key predictor of knowledge-intensive team environments and directly influence an individuals' willingness to engage in active knowledge management.*

Next, and focusing on the discussion on tacit and tacit knowledge, an often underestimated aspect will be addressed targeting the level of abstraction compared with the cost of disembodiment.

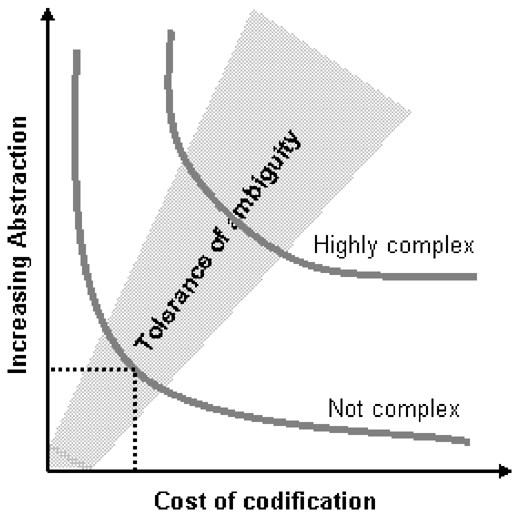
2.4.3 Abstraction levels - Complexity and the cost of codification

To fully understand the nature of knowledge transfer one has to take into account the issue of content and context. The following three situations in which expert knowledge is sought illustrate this topic (adapted from Snowden 2002):

1. A colleague with whom one has worked for several years asks a question, a brief exchange takes place in the context of common experience and trust and knowledge is transferred.
2. A colleague who is not known to the expert asks the same question. The discourse is now more extensive as it will take longer to create a common context, and when knowledge transfer takes place it is conditional: "phone me if this happens" or "lets talk again when you complete that stage" are common statements.
3. The expert is asked to codify his knowledge in anticipation of potential future uses of that knowledge. Assuming willingness to volunteer, the process of creating shared context requires the expert to write a book.

It is evident that each situation copes with a different level of abstraction, both implicit and explicit. Figure 2-7 pictures the level of abstraction compared with the cost of disembodiment, most frequently the cost of codification. The model was originally inspired by the I-Space (Boisot 1998).

Figure 2-7: Operation levels of abstraction



Source: Snowden (2002)

At the highest level of abstraction, where someone shares knowledge with himself there is a minor cost; one may keep notes but no one else has to read them. On the other hand if someone wants to share with everyone the cost becomes infinite, as the audience not only need to share the same language, but also the same education, experience, values etc. In practice there is a very narrow zone between the lower and upper levels of acceptable abstraction in any knowledge exchange. Highly complex knowledge with a high decay factor will rarely justify the cost of codification. As can be seen from Figure 2-7 the tolerance for ambiguity is broader for complex knowledge. This is because the populations able to use complex knowledge are generally smaller and will tend to have more homogeneity of value/beliefs systems (Snowden 2002). Thus, the level of abstraction can be regarded as an important determinant of knowledge transfer, much ignored in many knowledge management models.

2.4.4 Language - A Carrier of meaning

Language can be regarded as a 'tool' by which individuals communicate and by which they restructure problems in order to adapt them to their cognitive strengths (Clark 1997). There are several ways in which language influences the conditions for knowledge generation and sharing:

1. First, language has a direct and important function in social relations, for it is the means by which people discuss and exchange information, ask questions, and conduct business in society. To the extent that people share a common language, this facilitates their ability to gain access to people and their information. To the extent that their language and codes are different, this keeps people apart and restricts their access (Nahapiet & Ghoshal 1998).

2. Second, language influences our perception (Berger & Luckman 1967; Pondy & Mitroff 1979). Codes organise sensory data into perceptual categories and provide a frame of reference for observing and interpreting our environment. Thus, language filters out of awareness those events for which terms do not exist in the language and filters in those activities for which terms do exist. Shared language, therefore, may provide a common conceptual apparatus for evaluating the likely benefits of exchange and combination.

3. Third, a shared language enhances combination capability. Knowledge advances through developing new concepts and narrative forms (Nonaka &

Takeuchi 1995). However in order to develop such concepts and to combine the information gained through social exchange, the different parties must have some overlap in knowledge (Nahapiet & Ghoshal 1998). Boland and Tenkasi (1995) identify the importance of both perspective taking and perspective making in knowledge creation, and they demonstrate how the existence of a shared vocabulary enables the combining of information.

According to Bruner (1990) reality is imputed and constructed through the way people ‘narrativise’ their ongoing experiences. Meaning is a function of cultural tradition and culturally specific ways of thinking that are learned through the stories we tell that construct "not simply how things are but how things should be" (Bruner 1990, p. 39-40). Blackler et al. (1998) argues that language does not passively mirror the world, but rather speech is a practical act that shapes and negotiates meanings. Thus, project team operates within interpretive or discourse communities; for example, ‘project manager’ only makes sense within members of a project team, who understand the deep meaning of the term. Studies by Koskinen (2000) show how similar worldviews and situational connections of a supplier and a client helped them solve difficult technological problems together in the project although they did not speak the same native languages. From the above discussion the following tentative proposition emerges:

Given the importance of language focusing on interpersonal communication it can be expected that the effect of language on knowledge sharing activities in virtual settings is equally relevant.

After having discussed language as an important factor in knowledge management, the next part will focus on the supporting and/or hindering character of boundaries.

2.4.5 Boundaries – Support or Hindrance

Several sources, e.g. Brown & Erwee (1999), Erwee & Brown (2000), Parker et al. (2001) or Snowden (2001) studied boundaries and boundary-spanning aspects in the context of knowledge generation and sharing. Despres and Chauvel (1999b) argue that that humans think and act within a context, but also that first, their thinking and action create that context and second, the identity boundaries they fix around legal entities are social fictions contextually speaking, given the wide-ranging work interactions people have. Becker (2001) states that if knowledge retention and sharing are of interest the legal definition and legal boundaries of an organisation are of no help; the relevant boundaries have to be given by the transferability of knowledge. Furthermore, assessing junctures in networks that are fragmented across functional or hierarchical boundaries can be particularly informative for social or technical interventions that help to integrate disparate groups and hence preparing the ground for effective knowledge transfer (Cross et al. 2002b).

The value of a concept-based model such as Cynefin (see chapter 2.4.1 for details) is in its ability to assist in descriptive self-awareness within a work environment and to understand the flow of knowledge. By presenting clear boundaries between different forms of community, the organisation is more likely to recognise diversity and create alternative approaches to strategy determination and investment (Snowden 1999). The nature of the flows can indicate the sort of dominant environment and to some extend its likely future direction. Maintaining boundaries between communities can be vital in ensuring knowledge exchange (Snowden 2002). The same author argues that boundaries are possibly the most important elements in sense-making, because they represent differences among or transitions between the patterns we create in the world that we perceive.

In addition, one boundary might have different forms for different people, whose perceptions or circumstances make their experience of the boundary different. Snowden (2002) identified three basic levels of sophistication in the use of boundaries referring to his model (see Figure 2-6). *First*, one considers an awareness of crossing the boundary, so that one can respond quickly to new conditions after one has arrived on the other side. *Second*, one considers an awareness of approaching the boundary, so that one can sense when change is incipient and respond before the boundary is crossed (perhaps to cross it purposefully, perhaps to avoid it). *Third*, one considers managing the boundary and the perceptions surrounding it. Snowden and Kurtz (2003) found that in using boundaries as part of the Cynefin framework different people, with different training and personalities; seem to benefit from different uses of boundaries. People who are used to classifying items into categories benefit from removing boundaries. However, people who are used to thinking in a more fluid way - about gradients rather than boundaries - seem to benefit more by constructing boundaries than by removing them. Based on the above discussion the following tentative proposition emerges:

Boundaries, either visible or invisible, represent not necessarily barriers to knowledge sharing in virtual settings, but might act as reframing elements necessary for context-related sense making.

In summary, the discussed sense-making and organic approach advocates the notion that the dogma of scientific management, hypothesis-based consulting and the generalisation of best practice from multi-client or multi project studies are inhibiting factors in progressing to the new levels of conceptual understanding required to develop and implement more effective knowledge focused initiatives. Related contextual aspects and important social-cultural facets like culture, abstraction levels, language and boundaries have been described and discussed. The next section will now take a network perspective on knowledge and its management and will address theoretical fundamentals as well as practical tools / approaches.

2.5 Knowledge and Social [Informal] Networks

Business structures, whether formally hierarchical, networked or virtual, have become more ambiguous and fluid as technology has connected people globally. People rely very heavily on their network of relationships to find information and solve problems - one of the most consistent findings in the social science literature is that who you know often has a great deal to do with what you come to know (Granovetter 1973; Lave & Wenger 1991; Szulanski 1996). Still practical experience as well as scholarly research reveals a significant difficulty in getting people with different expertise, backgrounds, and problem-solving styles to effectively integrate their unique perspectives (Dougherty 1992; Fiol 1994; March & Olsen 1975).

As Cross et al. (2002b) points out that just moving boxes on an organisational chart is not sufficient to ensure effective collaboration among high-end knowledge workers. Movement toward de-layered, flexible organisations and emphasis on supporting collaboration in knowledge-intensive work has made it increasingly important for executives and managers to attend to informal networks within their organisations. Performance implications of effective informal networks can be significant as the rapidly growing social capital tradition has indicated at the individual, team, and organisational levels (Hansen 1999; Lin 2001; Podolny & Baron 1997). Yet while research indicates ways managers can influence informal networks at both the individual (Baker 2000) and whole network levels (Krackhardt & Hanson 1993;

Krackhardt 1994), executives seem to do relatively little to assess and support critical, but often invisible, informal networks in organisations (Galbraith 1995; Heckscher 1994). Next, the characteristics and managerial implications of a social network perspective will be presented and discussed.

2.5.1 The Social network perspective

Among the fundamental explicative principle of the social network perspective is the idea that the structure of social interactions enhances or constrains access to valued resources (Brass 1984; Ibarra 1993). Resources exchanged through informal networks include work-related resources, such as task advice and strategic information, but informal networks also transmit social identity (norms) and social support (Podolny & Baron 1997). Referring to Wasserman and Faust (1999) the social network perspective encompasses theories, models and application that are expressed in terms of relational concepts or processes. In addition to the use of relational concepts, the authors highlight the following characteristics:

- Actors and their actions are viewed as interdependent rather than independent, autonomous units.
- Relational ties (linkages) between actors are channels for transfer or “flow” of resources (either material or nonmaterial).
- Network models focusing on individuals view the network structural environment as providing opportunities for or constraints on individual action.
- Network models conceptualise structure (social, economic, political etc.) as lasting patterns of relations among actors.

Wasserman and Faust (1999, p. 7) stress that the network perspective differs in fundamental ways from standard social and behavioural research and methods. The authors argue that “…rather than focusing on attributes of autonomous units, the associations among these attributes, or the usefulness of one or more attributes for predicting the level of another attribute, the social network perspective views characteristics of the social units as arising out of structural or relational processes or focuses on properties of relational systems themselves”. Thus, in essence relational ties among actors are primary and attributes of actors are secondary. The task is to understand properties of the social structural environment and how these structural properties influence observed characteristics and associations among characteristics. The theoretical rationale of network research is the argument that behaviour is affected by the kinds of ties and networks in which people are involved (Wellman & Berkowitz 1988). In this context, it is important to monitor and manage communication structures, and to align the communication structure to the task characteristics (Ahuja & Carley 1999).

From a more business focused point of view managers often launch new initiatives without understanding the inner working of a network, relying on the philosophy that more communication and collaboration are better (Cross & Parker 2004). Sometimes these initiatives have the desired effect, but often results are not positive e.g. decision makers can become consumed and employees get overloaded with email, meetings and requests for help. Cross and Parker (2004) argue that because of the fact that collaboration has a cost (Handy 1994; Miles & Snow 1986) managers need to take a more focused approach. The authors conclude that targeting more strategic points within the organisational “fabric”, e.g. using Social Network Analysis (SNA); can quickly increase effectiveness, efficiency and opportunities for innovation.

After having laid the necessary foundation, the following part will now describe knowledge relationships and related concepts in more detail.

2.5.2 A network view of knowledge relationships

The transfer of knowledge is an interactive process (Haythornthwaite & Wellman 1998) and the nature of knowledge transfer is affected by the types of relationships people have (Hansen 1999; Teigland & McLure Wasko 2000). Knowledge workers in virtual project teams must be able to navigate through a web of complicated virtual social networks that exist around them, and are often only visible to those who know where to look. The extent that an individual’s “mental knowledge map” matches the actual knowledge network, directly affects their ability to forge relationships, and to gain access to new sources of knowledge (Contractor et al 1998). The IBM Institute for Knowledge-Based Organisations has used social network analysis to study the importance of informal networks in knowledge creation and transfer (Cross et al. 2002b). In this context, Falkowski and Ray (2000) found hidden strengths that could be leveraged and points where individuals and geographies were not fully involved (Cross et al. 2002c).

In their research Cross et al. (2002a) found out that it was important to look at social networks from more than a simple communication or information-flow perspective. The interventions they found to be effective in improving specific networks of people often have more to do with helping groups know what the others know and ensuring safety and access among people. With this realisation, they began to focus less on communication and more on the knowledge-based dimensions of relationships that make them useful in sharing and creating knowledge. Cross et al. (2002a) identified four dimensions tend to be critical for a relationship to be effective, in terms of knowledge creation and use:

Knowing what someone knows. In deciding whether or not to seek out an individual for information or advice, a person must have some perception of the relevance of the other person's knowledge, skills and abilities in relation to the current problem. Thus, understanding how well members of a group know each others' knowledge skills and abilities is a first step to understanding how effective they are in terms of knowledge sharing and creation.

Gaining timely access to that person. Simply believing someone has relevant knowledge does not necessarily result in a contact facilitating knowledge creation. Gaining access to that person's thinking in a sufficiently timely fashion is a requisite as well. To some extent, access is a product of the social fabric of the work environment and influenced by power inhering in positions of formal authority or informal structure. Access is also influenced by the physical and technical environment, as impediments to people being able to connect dramatically reduces the likelihood of their being consulted.

Creating viable knowledge through cognitive engagement. Of course, access alone does not ensure effective knowledge transfer or creation. One way people can distinguish themselves from a file cabinet or database in terms of knowledge transfer and creation is by actively helping other people think through problems they are trying to solve. In turning to others for information or advice, people who are willing to first understand the other person's issue and then actively shape their knowledge to the problem are more helpful in terms of knowledge creation. This often stands in extreme contrast to those people who simply dump information without taking the time to actively engage in problem solving.

Learning from a safe relationship. Finally, relationships have properties that affect the degree of learning or creativity emerging from interactions. When a person asks another person for information, they inherently become vulnerable because “help seeking implies incompetence and dependence, and therefore is related to powerlessness.” To ask for information is to give power to someone - trust that this power will not be employed against you is an important precursor to deciding to engage with someone. Further, relationships characterised by a degree of safety or trust also provide room for exploration or creativity in interaction. Relationships characterised as safe or secure improve knowledge creation by allowing room for creativity and learning.

Research has shown that network ties are useful predictors of how information flows in organisations and can be better predictors than formal structures (e.g., Stevenson & Gilly 1991). Recent research suggests that social networks also contribute to knowledge transfer within organisations (Hansen 1999). It is important to note that individuals can obtain information not only from their personal social ties, but also from the social ties of those to whom they are related. Research on the 'small world' phenomenon (Milgram 1967), for example, supports the notion that two unrelated individuals can connect with each other through their acquaintances, the acquaintances of their acquaintances, and so on. Given that individuals have a general preference for obtaining information from other people, rather than from documents (Allen 1977; O'Reilly 1982), it can be expected that social networks have an important influence on knowledge generation and sharing. Having addressed more theoretical and conceptual aspects of knowledge networks and relationships, the following section will now describe ways and techniques which can be utilised to investigate knowledge-enabled work environments in sufficient detail.

2.5.3 Tracing relationships: Social Network Analysis

Social Network Analysis (SNA) is a research technique that looks at the relationships between people and organisations. Sociologists and communications scientists use this tool to describe relationships, examine information flows and analyse patterns that develop between individuals and organisations (Wasserman & Faust 1999). While SNA has been used extensively in sociology and anthropology (Mead 2001), its application to knowledge management is limited. Probably the most useful feature of SNA is its visualisation capabilities. Data can be collected and processed into useful graphics that depict several unique attributes of a given network.

Mead (2001) quotes two approaches targeting the investigation of social network: ego centred and whole networks. *Ego-centred analysis* looks at a particular individual and the connection that a person has with others. It can determine a team member's individual contacts, the information that passes between participants and the strength of each relationship. This approach is useful when the population is large or the boundaries are hard to define (Wellman 1982). On the other side, the *whole network* approach is useful when the boundaries of a network are easily established. This perspective describes all the relationships between each member of an organisation or group. While whole network analysis can be applied to networks of any size, the analysis is most useful when data can be collected from every member of the investigated network.

Because communication and knowledge transfer are dynamic processes, both often change during the life cycle of a project (see section 2.2.2 for details). SNA can be used as a good tool to cope with this challenge and to analyse a project team in terms of a unique set of network attributes that include roles, linkages and metrics (Mead 2001):

Roles. Role articulation defines the team member components of any communication network (see also chapter 2.3.3). Previous research by Roberts and O'Reilly (1978) as well as Tichy and Fombrun (1979) have identified four roles including a group member, a group linker or liaison, an isolate and a star. Role analysis can add depth to organisational charts or projects structures by identifying stakeholders that act as information or knowledge hubs and discovering team members that are isolated from project communication.

Network linkages. During the course of a project, team members develop linkages with each other as they exchange the information and knowledge needed to complete the project. These linkages have several different properties including symmetry, direction, reciprocity and multiplexity (Monge & Eisenberg 1987 as cited in Mead 2001). The degree to which two team members have similar status or relationships is explored by the *symmetry* parameter. SNA can be used to identify the *direction* of communication flows, thus downward, upward and horizontal, within a given work environment (Goldhaber 1986). *Reciprocity* measures the intensity and direction of specific communications between individuals and is useful in analysing feedback loops between network members. Finally, *multiplexity* examines the extent to which individuals communicate beyond their topic area or areas of influence.

Metrics. SNA can also be used to determine several key characteristics of a network. *Size* is simply the sum of the number of individuals or nodes in a network. Network *density* is computed by dividing the actual number of linkages by the number of possible linkages and describes how well a team communicates. Dense networks have a high degree of teamwork because there is considerable communication between all members (Mead 2001), whereas loose networks are typically comprised of isolated individuals who like to work autonomously (Garton et al. 1997). The variable of *centrality* is used to determine the participants with the highest number of connections to other members of a network. Centrality analysis can be applied to identify project stakeholders and reveal project communication barriers. Referring to the issues and notion addressed in this section the following tentative proposition emerges:

> *Based on the fact that people rely very heavily on their network of relationships to find information and solve problems the investigation of project-related social networks might yield important insights targeting knowledge creation and sharing.*

In summary, a social network perspective implemented using SNA provides insight into collaborative behaviour within and across boundaries that can yield a similar purchase on performance improvement opportunities as process mapping did for reengineering in the early 1990's (Rummler & Brache 1990). This section described and discussed the method and corresponding features to illuminate informal structures and linkages in order to identify not only clear breakdowns in cooperation and sharing but also opportunities to strengthen viable but imperfect elements of the 'collaborative fabric'. The subsequent section will address the aspect of virtualness within the context of team environments.

2.6 Virtual Team Environments

2.6.1 The Challenge of Virtual Teams

While the potential payoffs are great (see section 1.1 and 1.3), new organisational forms like virtual project teams have a "dark side" that tends to slip out of focus (Picolli 2000). Virtual teams, due to their limited ability to interact in a face-to-face environment, operate in a context that is dramatically different from that of their traditional counterparts. Authors have suggested that the dispersion of team members may engender low levels of trust and cooperation (Handy 1995b; Nohria & Eccles

1992), a reduction in employees' well-being and satisfaction (Victor & Stephens 1994) and may ultimately reduce the overall ability of the team to perform adequately. Organisations that implement virtual teams must be able to effectively use Information Technology (IT) and Communication Technology (CT) to rapidly mesh the individual skills of strangers into interdependent work products (Lipnack & Stamps 1997).

Table 2-4: Challenges of Virtual Teams

Type of challenge	Description
Communications	Traditional social mechanisms are lost or distorted
	Communication dynamics such as facial expressions, vocal inflections, verbal cues, and gestures are altered
	Distinctions among member's social and expert status lost or distorted
	Inhibition in building trust
	Communication process dysfunction
Logistics	Multiple time zones make scheduling meetings as well as travel very difficult
Technology	Technophobia
	Need for proficiency across a wide range of technologies
	Team membership bias toward individuals skilled at learning new technologies
Project Management	The quality of project management is a vital issue
	Distributed working requires more of a group management and co-ordination overhead than standard face-to-face meetings
	The solutions at the disposal of team leaders to address the problems of teamwork are quite different in the Virtual Teams from the face-to-face. In the virtual environment, much of the control and reward capabilities of the leader are reduced so that the leader must create inventive solutions to address team problems.
Culture	Potential for multiple cultures requires greater communication skills
	Unrealistic cultural expectations
	Communication may be distorted through cultural misunderstandings/biases

Source: Developed from Kayworth & Leidner (2002); Kayworth & Leidner (2000)

Despite the efficacy of modern innovative technologies, they may cause several problems not typically found in traditional group settings (see Table 2-4). Since communication media may differ in their ability to convey 'social presence', information-rich nonverbal cues, such as facial expressions, voice inflections, and gestures, may be lost or distorted through IT/CT that lack the social presence inherent to face-to-face environments (Kiesler & Sproull 1992; Warkentin et al. 1997). The severity of this information loss will be determined by the richness of the technology being used. In addition, important social/contextual information, such as member's social status or level of expertise, may be lost or distorted in virtual team environments characterised by high levels of anonymity (Dubrovsky 1991). Further, the ability to develop relational links among team members may be hindered, which may negatively affect such outcomes as creativity, morale, decision-making quality, and process loss (Walther & Burgoon 1992). Finally, the lack of a social context may alter or hinder the process through which team members develop trust. As a result, virtual team communication through IT/CT may appear out of context and without focus, resulting in lost meanings, distortion, and misinterpretation of information (Kayworth & Leidner 2002).

In contrast to the evidence that new and innovative modes of communication may be possible through IT/CT-enabled work groups (Ahuja & Carley 1999), research suggests that virtual groups may still encounter significant problems in securing an sufficient communication between team members (Hightower & Sayeed 1995; Kayworth & Leidner 2002; McGrath & Hollingshead 1994). In this primarily asynchronous environment, characterised by non-linear, multi-threaded topics, team members may experience information overload as they attempt to cope with a seemingly disjointed set of communications (Hiltz & Turoff 1985). In such an environment, the non-sequential flow of information may eliminate or significantly reduce points of reference such that individuals may have difficulty in identifying how messages fit within the overall context of group communication (Hiltz & Johnson 1990). Another problem is that individuals in asynchronous environments may tend to send longer, more carefully crafted messages, which may place an even greater information processing burden on team members as they attempt to decipher and act on these messages (Hiltz & Johnson 1990).

Another challenge is that heavy dependence on technology requires a high investment on the part of users to gain proficiency with new information technologies. Given the differences in individual predispositions to learn new technologies, membership on virtual teams may be highly biased toward those individuals skilled at learning new technologies, and against those who experience technophobia (Townsend et al. 1998). Although there is a large body of literature on teamworking most of it is focused on conventional face-to-face teaming practices. Referring to Bal and Teo (2000) there is only a limited amount, though rapidly growing, of literature focusing on virtual team working.

In global virtual teams environments composed of members with diverse ethnic, national, as well as organisational backgrounds, communication requirements may be even more demanding. As team members communicate, they will tend to filter information through their inherent cultural biases, thereby giving rise to a potentially broad range of misinterpretations or distortions (Solomon 1995). Although these cultural differences bring a greater variety of perspectives to bear on a problem domain, they may also create additional communications challenges for team members.

Duarte and Snyder (1999, p. 55) identify three categories of *culture* that can affect a virtual team. They are national, organisational, and functional culture. Based on research results from six dimensions of *national culture* identified by Hofstede and Bond (1998), Duarte and Snyder (1999) discuss the behaviour of team members and propose technological considerations to facilitate communication for virtual teams. Table 2-5 summarises the discussions of Duarte and Snyder (1999).

Table 2-5: National cultural dimension: definition and technological consideration

Cultural dimensions	Definition	Technical Considerations
Power distance	Extent to which the less powerful members expect that power is distributed equally	Members from high-distance cultures may participate more freely with technologies that are asynchronous and allow asynchronous input. These cultures sometimes use technology to indicate status differences between team members
Uncertainty avoidance	Degree of structure required for a task	People from cultures with high uncertainty avoidance may be slower adapters of technology. They may also prefer technology that is able to produce more permanent records of discussions and decisions
Individualism-collectivism	Preference to act as individuals rather than as members of groups	Members from highly collectivistic cultures may prefer face-to-face Interactions
Masculinity-femininity	Extent to which masculine values are given priority over more 'caring' values	People from cultures with more 'feminine' orientations are more prone to use technology in a nurturing way, especially during team start-ups
High or low context	Amount of sensing and extra information needed to make decisions versus 'just the facts'	People from high-context cultures may prefer more information rich technologies, as well as those that offer opportunities for the feeling of social presence. They may resist using technology with low social presence to communicate with people they never met. People from low-context cultures may prefer more asynchronous communication
Long term-short term	Degree of parsimony, family orientation, virtuous behaviour, and acquisition of skills and knowledge	

Source: Adapted from Duarte & Snyder (1999, p. 59-60)

This table illustrates the close relationship between culture and choice of technologies for communication in virtual settings, like virtual project teams. Duarte and Snyder refer to *organisational culture* as shared basic assumptions that cover many complex areas such as perceptions of "the importance and nature of time (regarding project schedules and timetables), the organisation's relationship to its competitive environment (leading it or reacting to it) and theories about human nature (good or evil)" (Duarte & Snyder, 1999, p. 60). *Functional culture* refers to assumptions and practices developed by people who work in the same functional area and share similar background in terms of education, professional goals and skills (Duarte & Snyder, 1999, p. 63). They discovered that virtual team leader and members who come from organisations that often involve cross-functional teamwork would have fewer problems working in the team.

In the following sub-section the purpose and driving forces referring to this specific form of team environment will be identified and discussed in detail.

2.6.1.1 Goals and drivers of virtual teams

Any source focusing on team building advises readers of the importance of setting *goals and objectives* for a team (Bal & Teo 2001). Henry and Hartzler (1998, p. 14) define goals and objectives as "board statements of the desired end results with objectives that spell out the specific actions and activities needed to obtain those results". They identify four factors: charter, mission, vision, and goals and objectives that provide direction to a team. They suggest that since in virtual environments team elements are remotely distributed, gaining commitment and alignment around the team's purpose becomes much more difficult than for conventional teams. Virtual teams must clearly define their direction, including goals and objectives in the early stage of working together. Duarte and Snyder (1999) express similar views, they emphasise that a clearly understood statement of direction at the beginning of any team serves as a starting point for more detailed plans. In addition they add that the lack of physical contact in virtual teams may "erode meaning and understanding and make the link between charter and work more tenuous" (Duarte & Snyder 1999, p. 94).

Referring to Fisher and Fisher (1998) it is the ability to differentiate and integrate simultaneously that makes the primary difference between effective virtual teams and ineffective ones. Integration strategies refer to "organisational structures, common goals, communication systems and other processes that meld the differentiated specialist together to work toward a common cause and keep them focused on objectives that can be accomplished only through cooperation and collaboration". In the same context Lipnack and Stamps (1997) cite the importance of purpose to virtual teams. They describe that the clarity of purpose and the participatory process by which the group achieves it is ‘the best predictor’ of virtual team success (Lipnack & Stamps 1997, p. 57). Henry and Hartzler (1998) hold a very similar position by arguing that due to the lack of bureaucratic rules and regulations to guide team members, they must rely on their common purpose to stay aligned.

In the alignment model proposed by Haywood (1998) each team member is envisioned as a puzzle piece consisting of four parts: goals, process, tools, and skills. Team members do not fit unless they are aligned in all four areas, illustrating equal emphasis of four areas in building a successful virtual team. Similar to Henry and Hartzler (1998), Haywood emphasises the role of a written statement of project or team goals in evaluating team members for alignment (Haywood 1998, p. 64). It can be concluded that having clear goals and objectives at the formation of a team is important due to the lack of bureaucratic rules and regulations to guide the team. Although having goals is important, Fisher and Fisher (1998, p. 151) point out that having good goals is not sufficient unless they are used regularly as a tool for self-regulation.

Table 2-6: Summary of drivers of virtual teams

Main Drivers	Description
Organisational trends	Globalisation and increasing competition Mergers, acquisition, downsizing and outsourcing
Business requirements	Cross organisational product development Changes in contemporary products and services Offshore development and manufacturing
Technology	Advances in electronic communication technology Higher return on investment due to decrease in cost of bandwidth
Expertise	Greater and more in-depth expertise Leverage of organisational expertise Technical specialisation

Source: Bal and Teo (2000)

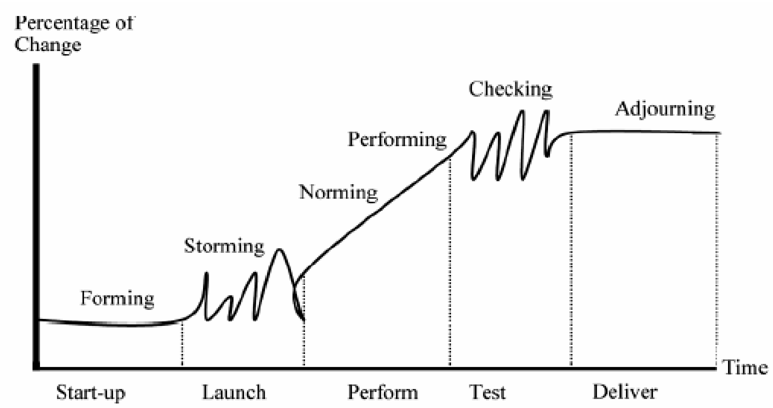
Focusing on *drivers or reasons* why companies form virtual teams Fisher and Fisher (1998, p. 134) identify that change in products and services, communication technology and recent organisational trends are some of the reasons that virtual teams became necessary. Duarte and Snyder (1999, p. 4) point out that virtual teams often are formed "as a reaction to a business requirements or as a result of programs that introduce new ways of working". Henry and Hartzler (1998, p. 2) identify that increasing globalisation and competition, the need for diverse talents and expertise, leverage of organisational expertise and advances in electronic communication technology are four of the drivers of virtual teams. They state that increasing globalisation in the market place demands organisation to change in order to be closer and more responsive to customer's needs. Haywood (1998, p. 3) identifies that trends such as mergers, acquisitions, downsising and outsourcing, technology, offshore development and manufacturing and technical specialisation are factors which contribute to the rapidly growing trend in implementation of virtual teams. Analysing the factors or drivers identified by the authors reveals some main drivers of virtual teams which are summarised in Table 2-6.

After having described and contrasted relevant goals and drivers of virtual teams the next section will take a more detailed look on how these teams develop and evolve.

2.6.2 Virtual team life cycle

Henry and Hartzler (1998, p. 60) recognise that virtual teams also go through similar stages compared to the traditional team life cycle: forming, norming, storming, and performing. Lipnack and Stamps (1997) have a more detailed discussion on this issue, like Henry and Hartzler (1998), they use the "stages of small group development" developed by Tuckman in the 1960s to explain the life cycle of a virtual team, shown in Figure 2-8. Lipnack and Stamps (1997, p. 142) point out that the ripples on the "S" curve which are called stress points, indicate "times of natural turbulence and potential conflict". Predicting when the stress points are likely to occur can help the team minimise the impact of conflict.

Figure 2-8: Team life cycle: The ‘Stress S’ team process



Source: Lipnack & Stamps (1997)

Figure 2-8 shows two major points in a traditional team cycle where stress is like to occur near the start-up stage of a team and not long before its end. The authors briefly explain what happens in the various stages of the life cycle (Lipnack & Stamps 1997, p. 144):

Phase 1: start-up (slowing). This is the stage where the team's initiators generate interest, gather information, and explore ideas. While the team struggles to arise against resistance, this stage can be extremely long or incredibly brief.
Phase 2: launch (transition). This is the stage where the team is ready to perform, shaping its vague objectives, establishing leadership, making plans, finding resources, obtaining commitments and acknowledging norms. This transition stage between the slowing loops of phase 1 and growing loops of phase 3 determines the success or failure of a team. Virtual teams can take a longer time to go through this stage than normal teams.
Phase 3: perform (growing). Work and results accumulate and leading the team progresses toward the goals. Team members meet and overcome problems together.
Phase 4: test (transition). Team reviews results, finalises features, and limits resources. The process changes from growing to slowing. Some teams never reach this stage.
Phase 5: deliver (slowing). This is the stage where the team delivers results, provides support, wraps up details, and celebrates the end of its tasks. The team stabilises at a new level after completion of a development cycle of establishing change. This could be the end of the team life cycle or the beginning of another new cycle.

In contrast, the maturity model for distributed teams proposed by Haywood (1998) illustrates the different stages a virtual team will go through before achieving its maturity stage. The purpose of this model is to highlight certain characteristics and key problem areas at each level so that goals, processes, tools, and skills (the four alignment areas of Haywood's alignment model) can be properly aligned. The situation of teams at each level (Haywood 1998, p. 72) is described below:

Ad hoc level: Teams consistently under-perform collocated teams.
Basic level: Teams achieve a performance level similar to their collocated counterparts. They have begun to derive some of the benefits of a virtual organisation but they are facing problems with time and efficiency taken by infrastructure.

Standardised level: Teams outweigh the problem and derive benefits from operating as a virtual organisation.

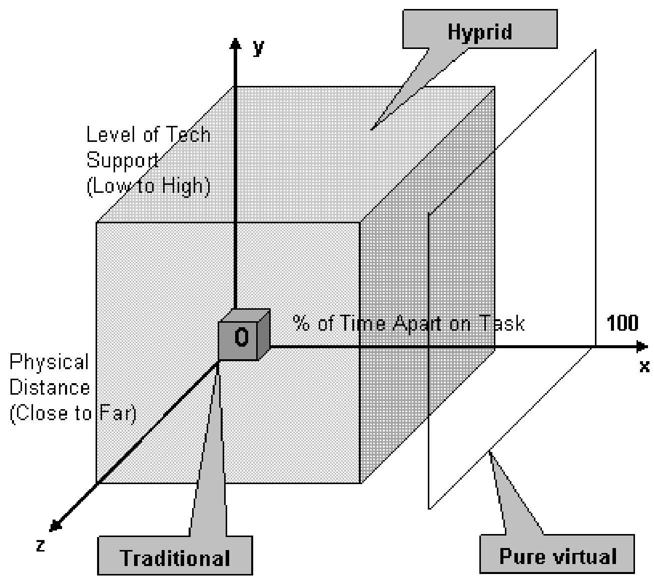
Optimising level: Teams having members to work any time, any place. New members can be integrated and released easily.

Although much used in business and academia the concept of virtualness is not an absolute state or condition but more a continuum which will be addressed next.

2.6.3 Dimensions of virtualness

Griffith et al. (2003) developed a characterisation model with three distinct team categories: traditional, hybrid and pure virtual (see Figure 2-9). The y-axis represents the level of technological support used by the team. Technological support (either electronic or otherwise) may include communication, documentation, and/or decision support capability. The x-axis depicts the percentage of work that the team does with its members distributed across time or space. The z-axis symbolises the distribution of the physical locations occupied by the team members.

Figure 2-9: Dimensions of Virtualness



Source: Griffith et al. (2003)

Griffith et al. (2003, p. 268) express the opinion that teams that never meet face-to-face are different in a nonlinear way from teams that do have regular physical contact. Most of today’s organisational teams are likely to fall into the large hybrid category composed of team member who interact over time, according to the need of the moment and through media, with the amount of face-to-face contact determined by their own adaptation and structuration of the process (DeSanctis & Poole 1994 as cited in Griffith et al. 2003). More virtual teams may be able to draw upon a larger network for sources of knowledge due to their expected greater informal diversity (Griffith & Neale 2001). Further, as teams differ in their amount of virtualness, so too do they differ in critical ways regarding the transfer of knowledge from their participants to the team and to the involved organisations (Griffith et al. 2003).

Summing up this section, it becomes clear that virtual team members require a different mix of skills to those of traditional teams. These include project management and skills in liaison/negotiation (May & Carter 2001), skills to deal with cultural and language complexities (McDonough et al. 2001) and skills in developing a shared vision or goal, developing a sense of team identity, getting a state of mutual trust, communicating effectively, enjoying the group process and successful interpersonal processes (Tullar & Kaiser 2000). The last section of this literature review will now focus on the immediate discipline of this dissertation, hence trying to integrate the aspects of project management, virtual team environment as well as the effective generation and sharing of knowledge to build the necessary theoretical and conceptual foundation for this research.

2.7 Knowledge Management in Virtual Project Teams

2.7.1 Dispersedness of Knowledge and its Management Implications

While there has been much progress in understanding knowledge and knowledge management practices in traditional organisations or projects, some questions still remain unresolved. Hayek pointed out that the division of labour is accompanied by a division of knowledge as well (Hayek 1945). According to the author dispersed knowledge can never be given to a single mind and thus '"never exists in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all separate individuals possess" (Ibid, p. 519). There are clear limits to the centralisation of knowledge (see chapter 2.3 and 2.4), and this therefore can not be the only strategy applied by knowledge managers in dealing with dispersed knowledge. Becker (2001) identified three drivers behind the problems arising from dispersed knowledge: large numbers, asymmetries and uncertainty.

Large numbers have two effects on knowledge workers. On one hand, there is an increase in resource requirements, based on the fact that the process of drawing those fragments together has to be repeated more often. On the other hand, large numbers promote intransparency, because if there are ‘too many’ elements, actors tend to lose overview. Fransmann (1998) pointed out that dispersed knowledge leads to knowledge *asymmetries*. Problems are caused because among other things: (1) the way in which tasks are allocated defines limits of what knowledge workers are able to do; (2) learning is process-dependent and capabilities are being created and developed though learning by doing; (3) what one learns and what capabilities one develops depends and is limited by what one does, as a result of the division of labour and specialisation.

Thus, asymmetries have a two-fold effect: first, they entail learning and competence development potentials and second, at the same time they increase differences between interpretative frameworks and the knowledge and competence profile of the different knowledge workers and thus make interpretation more difficult (Becker 2001). Minkler (1993) and Tsoukas (1996) identify *uncertainty* as the last driver by which dispersedness can causes managerial problems. Dispersed knowledge causes structural uncertainty, a strong form of uncertainty that exists if a decision-maker cannot *ex ante* specify all relevant alternatives or outcomes (see also chapter 2.4.1). Based on the fact that dispersed knowledge, e.g. in virtual project settings, is a ubiquitous phenomenon in contemporary management and economics the following part will discuss relevant member characteristic and roles as well as appropriate strategies for dealing with it.

2.7.1.1 Leadership and team roles

The role of the leader and the function of the *leadership* role have been given considerable attention by several authors in discussion on building successful virtual teams. Generally spoken the virtual team leader needs to link the distributed minds (knowledge workers) together without superimposing his/her own mind on top of the team members. Due to the characteristics of virtual teams, the role of the virtual team leader is undeniably important. However, even a successful virtual team needs more than just a single leader. Lipnack and Stamps (1999, p. 121) quote a statement made by Parker (1991), "In successful teams, leadership is shared", to emphasise their unequivocal point of view. They further expand that having shared leadership is inevitable for virtual teams when they deal with complex issues and problem.

Duarte and Snyder (1999) and Fisher and Fisher (1998) also address similar issues. Duarte and Snyder (1999, p.209) explain that from time to time, leadership shifts to a team member who has certain expertise to deal with specific problems. However, they remind us that the team leader (e.g. the project leader) is always accountable for the team results. In this context Lee-Kelley (2002) defines the *project manager*'s key role as to reduce uncertainty of outcomes and to protect technical integrity without risking the financial viability. Cole (1996) calls this management of people to achieve set objectives as ‘exercising leadership’. However, there is increasing consensus that the person in charge of a project regardless of titles (e.g. project leader or project manager) is vital to the project as its main focal point (Harrison 1992). To ensure project success, this leader or manager has to be able to influence the behaviour of others in his/her team.

If leadership is continuously rotated from member to member, then how do virtual teams define *team member roles*? Fisher and Fisher (1998, p. 26) emphasise the importance of defining team member roles and responsibilities in any team's success. Virtual project team members are facing tension in differentiating their individuality while at the same time trying to integrate themselves in the team. Duarte and Snyder (1999, p. 125) and Lipnack and Stamps (1997, p. 113) coincidentally point out that the situation gets more complicated when tasks require collaboration and coordination between team members and people of higher work status. Lipnack and Stamps (1997) clarify that ‘me’ and ‘we’ are complements, not opposites. Roles can become unclear due to a lack of bureaucracy that defines the job description and reporting structure of employees, Lipnack and Stamps (1997), suggest that to a significant degree, virtual teams should be self-managing. This coincides with the sentiment expressed by Fisher and Fisher (1998). In their discussion on defining team member roles, they highlight that when a sense of shared leadership is created in a knowledge team, "individuals will exhibit a high degree of self-direction" (see also chapter 2.6.1.1).

Duarte and Snyder (1999) fill in the gap left by Lipnack and Stamps (1997) by further classifying roles in virtual teams into two different types. They stress that virtual team members usually need to "behave autonomously" to perform activities performed by a traditional team leader (Duarte & Snyder, 1999, p. 122). Those activities include networking, resolving conflicting royalties, and clarifying ambiguous situations. They further expand that virtual team members are required to take the initiative to coordinate and collaborate with team members, with other people in the organisation, and with external partners (see also chapter 2.5.2). Duarte and Snyder (1999, p. 126) found that in order to ensure success in collaboration and coordination and in autonomy roles, virtual team members should posses extra competencies in addition to traditional team competencies (see also chapter 2.3.3 and 2.6.3).

2.7.2 Strategies for the management of dispersed Knowledge

A **first approach** to deal with dispersed knowledge is to substitute knowledge by access to knowledge. Nahapiet and Ghoshal (1998) introduced the idea to create *'information channels*' like social relationships (see also chapter 2.5.2) through which knowledge can be acquired. However, it has to be mentioned that this channel itself only provides the necessary, not sufficient requirement. In order for knowledge to be accessed, people also have to have the capacities for using, including 'absorptive capacity' (Cohen & Levinthal 1990; Nahapiet & Ghoshal 1998). The information channels have to turn into 'regular venues for the informal transmission of information, such that the process itself becomes tied to knowledge seeking and creation' (Powell 1998). This approach results in a shift from direct knowledge - 'know how' or 'know what' – to indirect knowledge: 'know whom' (Becker 2001).

The **second strategy** focuses on the capability to *complete incomplete knowledge*. Egidi (1996) suggests that 'in reality, individuals do not usually possess precise and detailed knowledge of organisational procedures; they have "incomplete" knowledge, and they are able to complete it by creating its messing components' (Egidi 1996, p. 307). From Nonaka and Takeuchi's (1995) perspective, actors possess a 'micro-skill' of knowledge creation – they are able to create, to fill in missing bits, to re-create them.

The **third strategy** to deal with a coordination problem is to design project structure with appropriate *coordination mechanisms*. The classical coordination mechanisms are price and authority (Coase 1937) – price working within the institution of the 'market', and authority within the institution of a 'firm'. Obviously, both aspects are not adequate for virtual project teams, composed of several organisation or partners. Here new ways have to be found to handle not only knowledge-focused mechanisms for project itself, but also the expectations and requirements of the involved organisations.

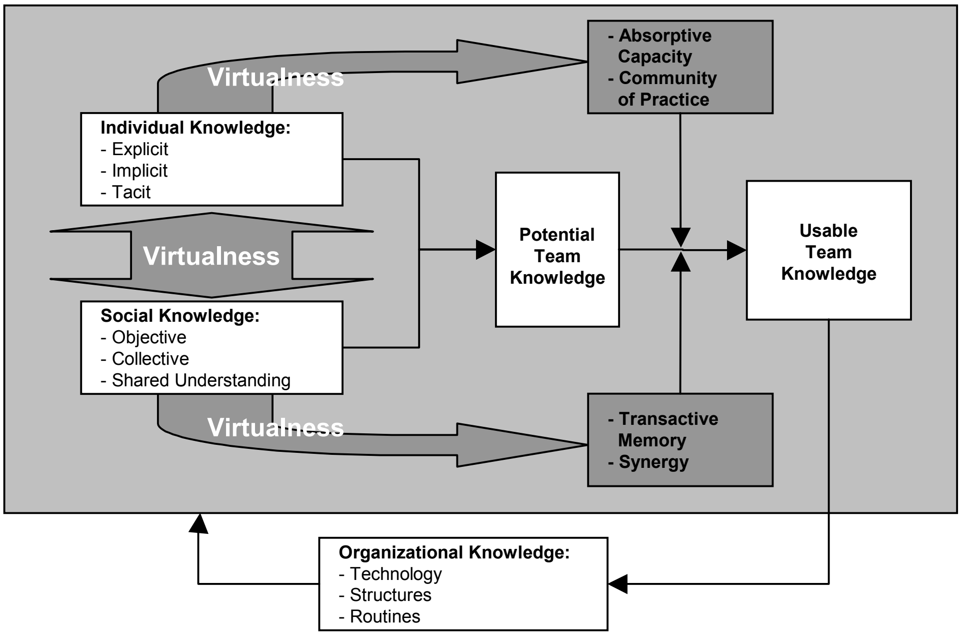
A **fourth approach** regarding dispersed knowledge is the *delegation* of tasks to sub-units, be it other project teams or individuals (Becker 2001). Assuming that at least some of the knowledge required is difficult and costly to transfer (see also chapter 2.4.3), this strategy also ‘economises’ on the transmission of information and knowledge by the specialisation of function (Arrow 1999). To decompose and spin-off parts to ease the burden of problem solving is almost always possible and easy to implement. But it has to be remembered that this leads to self-reinforcing effect: dispersedness is triggering of further division of labour, leading to a higher dispersedness of knowledge.

The **fifth and last strategy** for dealing with the problem of decision-making under uncertainty (to which dispersed knowledge contributes) is to *increase the information* available to the decision maker (Luce & Raiffa 1957). In this context – and under consideration of the quantity as well as functionality of modern IT/CT – the aspect of ‘information overload’ has to be always taken into account. Following this discussion on more strategic approaches toward the management of dispersed knowledge the next section will depict a model focusing on virtual team knowledge transfer in more detail.

2.7.3 Knowledge transfer in virtual teams

Griffith et al. (2003) developed a framework describing different types of knowledge; the moderating effects of absorptive capacity, communities of practice, transactive memory and synergy as well as the recursive link from resulting usable knowledge (see Figure 2-10). *Individual knowledge* is composed of the psycho-logical components that reside within the individual. In contrast to the already discussed more or less separate representations of knowledge (see also chapter 2.2.3) Griffith et al. (2003) argue for a knowledge continuum reaching from tacit (non declarative), over implicit (could be made declarative) up to explicit or objective knowledge. On the other hand, *social knowledge* is the collective type of knowledge that is publicly available or embedded within routines, culture or norms of the team (Spender 1996).

Figure 2-10: Team knowledge transfer



Source: Griffith et al. (2003)

The relationship between individual and social knowledge is twofold. On one hand, based on the degree of virtualness, knowledge can be shared when team members interact. On the other hand, as individual members work within the team, their own knowledge is developed and enhances as the individual and team knowledge is combined. This combinational process is influenced as well by the degree of team virtualness. Referring to Spender (1996 as cited in Griffith et al. 2003) individual-level explicit knowledge becomes objectified knowledge at the social level of analysis, while individual-level tacit knowledge becomes collective knowledge at the social level of analysis (see also chapter 2.3.1 and appendix A).

In teams, individual knowledge and social knowledge combine to form *potential team knowledge*. The model presumes that the level of *usable knowledge* will be determined by the absorptive capacity (Cohen & Levinthal 1990) of members of the team, the availability of relevant communities of practice and the team's transactive memory and synergy (Griffith et al. 2003). *Absorptive capacity* is a function of the individual's pre-existing stock of knowledge and is heavily dependent on tacit knowledge (Szulanski 1996). Referring to Leonhard and Sensiper (1998, p. 126) over time interactions among team members develops into *communities of practice*, which enable the further transfer of both explicit and tacit knowledge and provides a learning context to enact potential team knowledge. Griffith et al. (2003) assert that communities of practice develop when there are ample opportunities for informal contact.

Giving the fact that potential team knowledge resides differentially among the members of a team, group need a *transactive memory* system to help them effectively apply potential knowledge toward performance (Liang et al. 1995). In this context, Hollingshead (1998 as cited in Griffith et al. 2003) argue that shared experience, common language and joint decision making facilitate the development of transactive memory. The transformation of potential team knowledge to usable knowledge is also moderated by *synergy* (Watson et al. 1991). Synergetic knowledge is defined as knowledge created within the team – beyond the potential knowledge initially help by the team's individuals based on the idea that a team is greater than the sum of its parts.

Griffith et al. (2003) believe that knowledge can be useful to organisations while it resides in the organisation's individuals and teams. However, if others hold that knowledge, then it must be captured in a repository that is not dependent on individuals before it can be of value to the organisation (Levitt & March 1988). The technology, structure and routines of an organisation embody the past actions of the organisation and provide the context and foundation for knowledge within the individuals and teams. The discussed model by Griffith et al. (2003) represents a good starting point for the development of the necessary theoretical framework for this dissertation. One drawback is the fact that the approach only targets long term team environments, thus its suitability for short to mid-term virtual project environments is questionable. Following this discussion on team-based knowledge transfer the next section will provide important insights focusing on inter-organisational knowledge aspects.

2.7.3.1 Implications for Inter-organisational Knowledge Management

The proverb "who operates alone adds knowledge, who cooperates multiplies knowledge" (cited in Blecker & Neumann 2000, p. 78) emphasises the high importance of a systematic management of the resource knowledge in cooperative environments like virtual project teams. The same source argues that even although the tacit organisational and individual knowledge form the base for non-imitable and non-transferable core competencies, a successful exchange of knowledge is impossible in *short-term virtual settings*. This argument is based on the fact that due to the short-termness the necessary basic conditions for knowledge exchange are missing; e.g. common interest and knowledge targets as well as a high inter-organisational and interpersonal trust. Therefore in a short-term context the main function of a knowledge-oriented management is the reduction of conflicts, which appear in the thinking and acting of the respective project participants.

In *long-term virtual project environments*, knowledge represents the decisive basis for the competent and effective performance of the involved organisations and partners. To ensure a flow back of the aquatinted knowledge into the knowledge base of the companies involved several aspects have to be taken into account (Blecker and Neumann 2000). **First**, common knowledge targets and strategies (see also chapter 2.6.1.1) have to be developed and communicated as well as common agreements for a boundary spanning management of knowledge obtained. Simultaneously, the project members have to observe the internal and external available knowledge. Only because of this awareness regarding the own knowledge order and the competencies contained, project members can create, exchange and use knowledge in virtual settings.

Second, the structures, rules, principles and processes for a project-internal as well as inter-organisational order of knowledge have to be compiled and implemented. An intelligent form of strategically aligned and loose “knowledge architecture” is manifested in the virtual project structure. In this context, flexible regulation and control systems are needed (see chapter 2.7.5), which support the underlying knowledge processes. **Third**, in order to document experiences during and particularly after working on an inter-organisational project regular learning and reflection meetings have to be established. In this context, personnel development has to strengthen the technical and methodical as well as social and communicative competencies on an individual and organisational level. This common training not only leads to common knowledge and a standard of competence, but also supports cooperative working and the development of a common project language (see also chapter 2.3.1 and 2.4.1). **Finally**, effective reward and incentive systems and a project-based suggestion and improvement process can ensure the necessary ‘buy-in‘ regarding project team members.

After having addressed team-based and inter-organisational aspects of knowledge management the next section will describe one of the most important facilitators in virtual project environments.

2.7.4 The importance of trust

The basis of all trust is a presentation of the individual self as a social identity, which builds itself through interaction and which corresponds to its environment (Luhmann 1979). Trust is based on expectations and is therefore formed in the consciousness of project team members. According to Huemer et al. (1994) expectations are based on the trustor's perception of the motives and abilities of the trustee, i.e. the identity will be shaped by perceived motives and abilities. In the context of virtual project teams, trust ties together an attentive system, which forms the collective mind required for reliable performance. Referring to Weick et al. (1995) trust is imperative for co-operation and this co-operation is imperative for the development of mind.

Many conceptions of how trust develops emphasise that trust is a history-dependent and therefore, as well, a situation-related process (Koskinen et al. 2003). Based on the fact that trust builds incrementally in an accumulative way, there is not time in virtual project environments to engage in the usual forms of confidence-building activities that contribute to the development and maintenance of trust. Hence, people involved in virtual work forms have not the chance to get acquainted in a timely manner with the worldviews and situationalities of other team members. Therefore the trust emphasised in this sort of project teams is a unique form of collective perception and relating that is capable of managing issues of vulnerability, uncertainty, risk and expectations.

Meyerson et al. (1996) argues that people in project teams deal with each other more as roles than as individuals. A form of depersonalised trust may develop based on category membership, i.e. such trust occurs independent of the object of perception. Trust is, however, basically an individually accentuated phenomenon, because it is based on understanding with the help of which every member of a project team tries to understand other members' behaviour, state of mind, and motives (Koskinen et al. 2003, p. 16). The development of team member relationships (see also chapter 2.5.2) directs the process. When a feeling of trust becomes established it affects the perceptions of a member's motives more than does behaviour (Ibid.). Thus, trust has an indirect effect on the accessibility and efficient transfer of tacit knowledge. Accessibility determines the type and frequency of interactions that occur. Accessibility can be defined as an individual project team member's perception of his/her liberty or ability to approach or interact with another project team member. The greater the level of trust, the greater the level of accessibility and the better the opportunities for tacit knowledge to be transferred (see also chapter 2.3.2).

Interpersonal *trust* refers to expectations, assumptions, or beliefs about the likelihood that another's future actions will be beneficial, favourable, or at least not detrimental to one's interests (Frost et al. 1978; Gambetta 1988). Thus, the level of interpersonal trust is an important feature defining virtual worker's relationships with their interaction partners within in virtual project environment. Interpersonal trust is important from the perspective of a project manager and from the perspective of team members. From a project manager or supervisory perspective, trust acts as an implicit mechanism for control and coordination (Creed & Miles 1996). From a team member perspective, trust has been shown to enhance performance and diminish turnover intentions (Robinson 1996). Trust is therefore an important factor predicting virtual team member's adjustment.

Handy (1995b) suggests that trust must replace traditional means of control (see chapter 2.7.5) to realise the benefits of virtual work. Interpersonal trust has special significance in a virtual context because physical distance creates uncertainties regarding whether other's actions will be beneficial or favourable. Furthermore, virtual project team members cannot directly witness other's behaviours as easily as they can in traditional organisational settings where individuals operate in close proximity to one another (see chapter 2.6.3). Therefore, virtual workers must rely more heavily on expectations about how others may act. When trust is high, expectations will be positive and virtual workers will have confidence and diminished uncertainty. Thus, in a virtual project setting, interpersonal trust can prevent physical distances between organisational members from becoming psychological distances (O'Hara-Devereaux & Johnson 1994).

Virtual project members who feel that they have their project manager's trust are more likely to conform to given expectations. Conversely, project managers who feel trusted by their team members are more likely to adopt managerial approaches that are appropriate for the virtual work context, i.e. mentorship and support rather than monitoring and control (Wiesenfeld et al. 1999). Empirical evidence suggests that trust among peers in a virtual setting leads to more effective communication, collaboration and mutually acceptable ways of coordinating work (Jarvenpaa & Leidner, 1999). Next, after having discussed the supporting and integrative function of trust, the nature of control and its implications on knowledge processes in virtual project environments will be addressed. Based on the above discussion the following tentative proposition emerges:

Because virtual project environments often don't allow the engagement in usual forms of confidence-building activities the focused investigation of trust generation and maintenance in these settings might lead to new and better knowledge sharing models.

Next, the relevance of appropriate risk awareness and the nature of control mechanisms targeting knowledge sharing in virtual project environments will be addressed.

2.7.5 Risks and controls of Knowledge Exchange

Virtual environments, like the targeted Virtual Project Teams (VPT) involved in cooperative-cum-competitive business, may experience deviation between intended and actual knowledge flows (Loebbecke & van Fenema 2000). Parties may have – deliberately or unconsciously – different perspectives on the direction and boundaries (see also chapter 2.4.5 and 2.5.2) of the knowledge component in their exchange relationship. Understanding these risks is important to either avoid undesirable distribution of valuable knowledge as well as to actively support the necessary exchange of know-how and expertise during and at the end of the project live cycle.

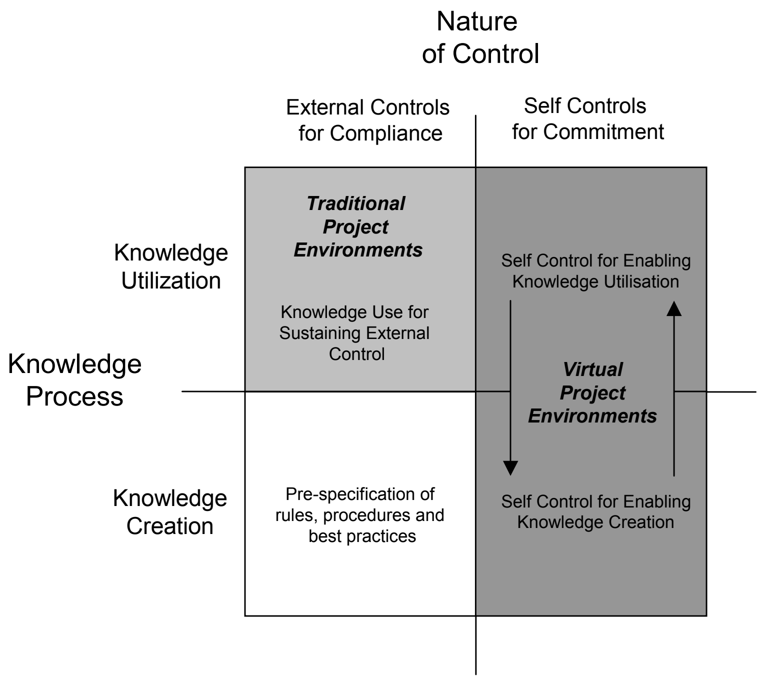
Explicit knowledge flows relate to the transfer and sharing of project documents or information systems. Coordinating these flows requires determining which knowledge project members are willing to share and reaching agreement on transfer modes. But despite project focused contracts and procedures, members can use the shared knowledge in adjacent business opportunities beyond their initial agreement. Hence, access to team members' knowledge repository seems a good possibility to absorb knowledge in excess of priorly agreed-upon boundaries. Alternatively, project partners may try to pull *tacit knowledge* on top of the explicit knowledge that was specified in a contract or mutual agreement. Assuming some degree of opportunistic behaviour, the receiving project member may employ dynamic tactics to enlarge the flow beyond initial agreements (Loebbecke & van Fenema 2000). Similarly, a member pretending to share tacit knowledge may in practice structure knowledge flows and thus reduce the value of cooperation to other project members.

As organisations or project partners engage in a fluidly evolving exchange process (see also chapter 2.3.2 and 2.5), they need adjustable and flexible *control strategies*.

The intention to cooperate is translated into a relational contract that broadly outlines areas of exchange and codes of conduct (Macneil 1978 as cited in Loebbecke & van Fenema 2000). It roughly structures scope, duration and content of exchange to provide a minimal backbone for steering the actual knowledge-focused interaction process over time. Snowden (2000) warns that the formal organisation will always attempt to creep into other spaces (see chapter 2.4.1 for details) through measurement and control, and this partially laudable endeavour needs to be controlled and channelled so that it does not inhibit the capacity of the team or organisation as a whole to develop to meet the demands of its environment.

On the human level, team members should be put into contact with other staff from their individual organisations to share recently acquired insight (Hamel et al. 1989). Long-term or remote cooperative endeavours, like virtual project environments, suggest job-rotation of team members to foster company-wide learning (Edström & Galbraith 1977). Although it has to be mentioned that this procedure may drag important know-how from the actual project away, therefore a conflict of interest between the project itself and the participating organisations and partners may arise. Novel insights are leveraged and anchored to prepare the organisation for subsequent competitive phases. Rotation also maintains the relationship between the organisation and its employees working on the fringe, and may avoid unwelcome turnover (Loebbecke & van Fenema 2000).

Figure 2-11: Control of Knowledge Management in traditional vs. emergent organisational forms



Source: Developed from Malhotra (2000b)

Malhotra (2000b) recognises self-control as the driver of human actor's behaviour and actions across instead of emphasising unquestioning adherence to pre-specified rules or procedures. Figure 2-8 illustrates the authors view by comparing the traditional model of knowledge management by compliance with a commitment-focused model for emergent organisational forms like virtual project teams. Instead of focusing on 'best practices', his model encourages development of a large repertoire of responses to suggest not only alternative solutions, but also different approaches for executing these solutions. The proposed model is based on the premise that "solutions to problems cannot be commanded… [they] must be discovered: found on the basis of imagination, analysis, experiment, and criticism (Landau & Stout 1979, p. 152)". Although this approach sounds interesting for organisational settings, it has to be analysed in which way this model interacts with actual propagated project management models (see chapter 2.2.2) and their underlying controlling philosophy. Based on the above discussion the following tentative proposition emerges:

> *Because project members may have – deliberately or unconsciously – different perspectives on the type and scope of shared knowledge as well the used control mechanisms an in-depth investigation of these inherent risks may yield important insights.*

In summary, this section of the literature review - focusing on the immediate discipline of "Knowledge Management in Virtual Project Teams" - presented several conceptual approaches and strategies aiming at [more or less] organisational virtual work environments. What is missing in this context is the combination and validation of extant knowledge management approaches with appropriate project life cycle models under consideration of the virtual work environment. Today project organisations are characterised through a more or less static role model, whereas innovative knowledge creation and sharing processes are highly dynamic in nature.

2.8 Summary

This chapter identified and reviewed the conceptual / theoretical dimensions of the relevant literature and discovered a portfolio of propositions and key issues that are worth to be further investigated. The review of literature, starting within the parent disciplines of project and knowledge management as well as social networks and virtual team environments, revealed important insights when considering knowledge dynamics in virtual project teams.

Webb (1996) argues that traditional *project management approaches* only partially fulfil all the objectives of a project and that new models, philosophies, and methodological frameworks should all tie in the issues and external factors that affect projects. And Lanzara and Patriotta (2001) point out that the epistemological orientation of the project management discipline tends towards a functionalist, managerialist framework of knowledge that readily accepts the link between knowledge and competitive advantage perceived elsewhere. The authors criticise this orientation for its lack of scrutiny on knowledge per se and its tendency to conceptualisation knowledge as an objective, transferable commodity.

Focusing on primary *knowledge management models*, e.g. Nonaka and Takeuchi (1995) or Despres and Chauvel (1999a), mostly all depicted models share similar elements and properties and follow a process flow or a life cycle approach. Despite their more or less simple layout and their easy delivery it is questionable whether these approaches can [practically] handle the dynamic and often complex situations associated with knowledge management in virtual project settings. Snider and Nissen (2003) as well as Fong (2003) developed concepts explicitly targeting knowledge processes in project environments. Snider and Nissen (2003, p. 10) advocate the perspective that "…formal knowledge such as documentation *results* from the work, whereas the (more) tacit knowledge flows associated with the vertical process *enable* the work to be accomplished in the first place". And Fong (2003) adds that project teams need to cross boundaries imposed both by the range of diverse professional disciplines and also by the hierarchical divisions of client, consultant and contractor before genuine work, problem-solving or pertinent knowledge creation could occur.

Giving the imminent notion that in an increasingly uncertain and complex business environment new models have to be found to enhance and/or substitute the rational, Newtonian perspective to knowledge management the Cynefin model by Snowden (2001) represents a more cultural-focused and sense making approach. In essence, the author supports the notion that many functionalist, managerial frameworks fail when we move to the management of intellectual capital: it is fine for process, quality and other activity that is mechanical in nature, but it fails when the principle component or actor is organic.

Knowledge workers in virtual project teams must be able to navigate through a web of complicated virtual *social networks* that flow all around them, and are often only visible to those who know where to look. Business structures, whether formally hierarchical, networked or virtual, have become more ambiguous and fluid as technology has connected people globally. People rely very heavily on their network of relationships to find information and solve problems - one of the most consistent findings in the social science literature is that who you know often has a great deal to do with what you come to know (Granovetter 1973; Lave & Wenger 1991; Szulanski 1996). In this context, four dimensions identified by Cross et al. (2002a), which are critical for a relationship to be effective in terms of knowledge creation and use, have been depicted and discussed. In addition, Social Network Analysis (SNA) has been addressed as a theory and a tool able to provide insight into the collaborative behaviour within and across boundaries by investigating several unique attributes of a given network.

Focusing on the last parent discipline of the literature review, it became clear that *virtual team* members require a different mix of skills to those of traditional teams. These include project management and skills in liaison/negotiation (May & Carter 2001), skills to deal with cultural and language complexities (McDonough et al. 2001) and skills in developing a shared vision or goal, developing a sense of team identity, getting a state of mutual trust, communicating effectively, enjoying the group process and successful interpersonal processes (Tullar & Kaiser 2000). Picolli (2000) emphasises that while the potential payoffs referring to new organisational forms like virtual project teams are great, they nevertheless have a "dark side" - thus inherent challenges that tend to slip out of focus.

Finally, targeting *knowledge management in virtual project environments* as the immediate discipline, several sources e.g. Becker (2001), Blecker and Neumann (2000) or Nahapiet and Ghoshal (1998) developed strategies for the management of dispersed knowledge, which have been described and discussed accordingly. Referring to team roles, Lipnack and Stamps (1999) argue that shared leadership is inevitable for virtual [project] teams when they deal with complex issues and problem; moreover the authors suggest that these teams should be, to a significant degree, self-managing (Lipnack & Stamps 1997). It has to be proved how this approach copes with the more or less static project management models and frameworks.

Griffith et al. (2003) developed a framework describing different types of knowledge; the moderating effects of absorptive capacity, communities of practice, transactive memory and synergy as well as the recursive link from resulting usable knowledge. In the context of virtual project teams, trust ties together an attentive system, which forms the collective mind required for reliable project and knowledge performance. The overriding insight, emerging from this literature investigation targeting knowledge management in virtual project teams, is a prevalence of inflexible, bureaucratic and thus often inappropriate management models and corresponding organisational standards and cultures. This increases the danger of chronic self-deception in the formal organisation, partly reinforced by the camouflage behaviour of individuals in conforming to the pseudo-rational models. Despite the existence of many theoretical [knowledge management] models and approaches it has to be said that no clear evidence could be found regarding their practical and successful utilisation in dynamic and complex real world scenarios like virtual project environments.

Table 2-7: Summary of identified key issues in literature review

Key issue	Chapter reference
Abstraction level	2.4.1 / 2.4.3
Boundaries	2.3.2 / 2.3.3 / 2.4.5
Communities	2.4.1 / 2.7.3
Culture	2.4.1 / 2.4.2 / 2.6.1
Informal networks	2.3 / 2.3.2 / 2.5.2
Language	2.3.1 / 2.4.1 / 2.4.4
Life cycle	2.2.2.3 / 2.3.2 / 2.6.2
Personal skills	2.2.3 / 2.3.3 / 2.6.3
Risks	2.5.2 / 2.7.5
Roles	2.3.3 / 2.5.3 / 2.7.1.1 / 2.7.4
Technology	2.2.2 / 2.6.1 / 2.6.3
Trust	2.6.1 / 2.6.3 / 2.7.3.1 / 2.7.4
Virtualness	2.6.3 / 2.7.3

Source: developed for this research

In summary, the review revealed a wide and interconnected field of disciplines with a recognisable focus on socio-cultural conditions as well as network-related factors and processes. Several - often interrelated - key issues emerged from the different disciplines discussed in the literature review (see Table 2-7). These issues, in combination with the elaborated tentative propositions, form the basis for the development of the interview protocol and the final selection of research issues in the subsequent chapter of this dissertation.

3 ANALYTICAL FRAMEWORK

3.1 Introduction

"The real danger is not that computers will begin to think like men,
but that men will begin to think like computers."
[Sydney J. Harris]

Due to the complexity and heterogeneity of the investigated phenomenon a type of convergent interviewing was used to discover further ideas and dimensions of the research problem. This chapter describes the preparation, execution and analysis of the interviews as well as the conclusive synthesis referring the key issues derived from the literature review. The refinement of the tentative research question and corresponding research issues will be discussed and the theoretical framework for this research explained.

3.2 Convergent interviews: Refinement of research focus

The first exploratory stage (see Figure 4-2) of this research has the purpose to develop a good grasp of the situation, that is, the facts, people and concerns, and to further identify ideas or dimension with which to clarify and refine the research focus and the model (see Figure 3-1 and Zikmund 2000; McPhail 2002). In a first step twelve *convergent interviews* with practitioners as well as academics (see detailed list in appendix K) have been conducted to support the literature review process, thus enhancing the necessary prior theory for the development of a first draft of the actual interview protocol for the subsequent main data collection (Nair & Riege 1995). Ethical considerations were incorporated into the process from the beginning, based on the ethical guidelines of the Research and Higher Degrees Committee of the Faculty of Business and Commerce of the University of Southern Queensland (see chapter 4.10 for details).

Referring to Dick (1990, p. 59) convergent interviewing is a useful tool to develop and refine a research problem because of its exploratory character and as it is more rigorous than other qualitative methodologies. According to Nair and Riege (1995) convergent interviews can be an integral part of a dissertation' literature review to reveal issues that will be tested with another methodology or they can be stage one of a two-stage data collection process. The same authors suggest that convergent interviews can be used to discover dimensions of a research area where methodologies or theories are established but not yet known be the researcher.

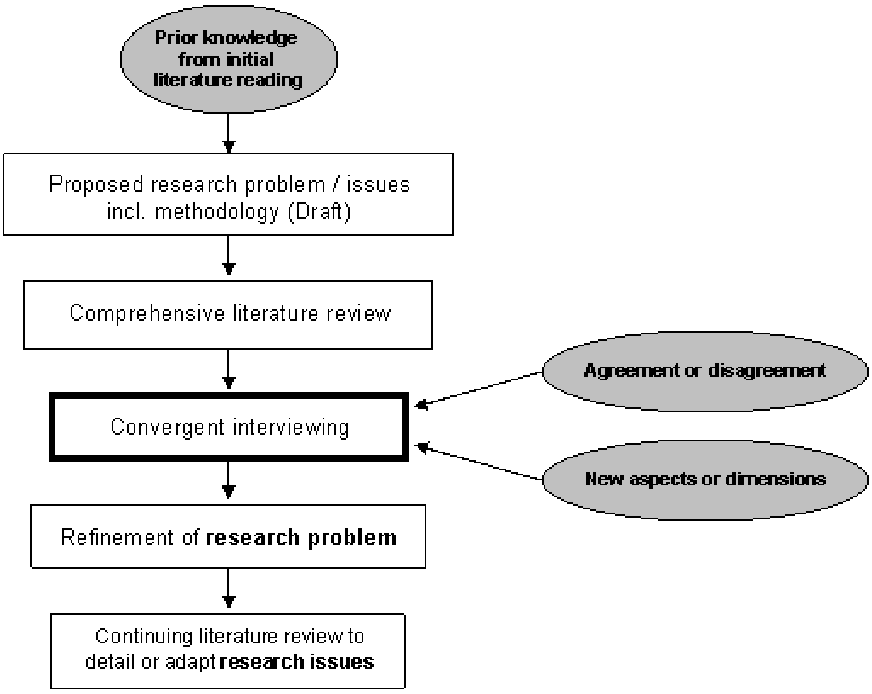
The strength of this qualitative method is based on the selection of participants and the combination of its unstructured content of topics, structured process and dialectical analysis (Dick 1990). At its beginning, each interview is almost completely unstructured and then proceeds into more specific questions to which the interviewer adds as he or she conducts more interviews and differences and opinions begin to emerge. After the first interview, the researcher initially develops a tentative interpretation of the data. As the research proceeds, probe questions are developed to test the pattern of agreements (convergence) or disagreements (divergence) of the respondent's interpretations (Nair & Riege 1995, p. 499). In addition, new aspects may arise in a later interview and appropriately designed new probe questions may be needed to test those new issues. The sequence of interviews terminates when a stable pattern of fairly clear agreements or disagreements emerge between all or most the interviewees, and where different attitudes and opinions are explained.

Based on Rogers (1983) as well as Nair and Riege (1995, p. 506) the benefits of convergent interviewing in the early stages of postgraduate research can be summarised as:

- The process is a very structured one that can handle 'messy', unstructured qualitative content.
- Time-saving – establishing an initial research problem and research issues is completed earlier in the candidature.
- Networks of academics and practitioners – an 'invisible' college are set up which help in later stages of the research process.
- The candidate develops confidence early in his or her research capabilities and in the importance and manageability of his or her research problem.

The flexibility of convergent interviewing arises out of the continuous refinement of the research content and process.

Figure 3-1: Use of convergent interviewing in the process of developing and refining the research problem / issues



Source: Developed from Nair & Riege (1995)

The next sections will describe the selection of interviewees, the structural and content-based development of the interview and important aspects regarding the rigidity as well as reliability of the data collection.

3.2.1 Interview Design and Preparation

The interview partners for this first stage of exploratory research have been selected on the basis of their knowledge and experience concerning virtual project teams in multinational enterprises, hence the u*nit of analysis*. Primary starting points regarding the identification of possible knowledgeable people have been the national and international project management associations like the Project Management Institute (PMI 2003), the International Project Management Association (IPMA 2003) and the German Project Management Association (GPM 2003). Appropriate activities started in June 2002 with a combination of individual telephone conversations with already known experts and a broader usage of emails to identify yet untapped sources. During the arrangement of the final group of interviewees care has been taken that the *sample* was as heterogeneous as possible (Dick 1990), therefore a small but extremely varied group of people has been put together including practitioners as well as academics spanning different professions like HR managers, organisational psychologists, consultants, project managers, analysts and others. The following Table 3-1 gives a general description of the chosen sample:

Table 3-1: Convergent Interviews - General sample characteristics

92 % of the respondents were males
65 % of the sample have their cultural roots in Germany
35 % of the interviewed individuals can be characterised as academics
66 % of the interviewees worked and/or lived abroad for a longer period of time
62 % of the group have significant experience (usually more than 7 years) as project managers

Source: field data

All chosen individuals can be characterised by their international and multi-cultural 'boundary-spanning' activities (Erwee et al. 2000). As recommended by Dick (1990, p. 25) and with respect to financial and other constraints the number of interviews (*sample size*) for this first stage of exploratory research has been set to twelve. Due to the mentioned restrictions all convergent interviews have been conducted via telephone, thus eliminating the judgement of non-verbal respondent behaviour. To insure a sufficient reliability and rigidity of the data collection the appropriate documentation, coding and analysing processes have been designed accordingly as described later.

Based on Dick (1990) the overall *interview structure* is characterised by four different stages (see Table 3-2). The introduction was used to present the researcher and the corresponding research. The purpose of the interview has been explained and the respondent been reassured focusing in issues like confidentiality and anonymity. After some small talk when the interviewee has settled down and a superficial rapport has been established the opening question (see Appendix B for details) has been asked. The purpose of the opening question was to encourage the respondent to begin to reveal her attitudes on the topic without placing any artificial limits on her replies. The formulation of the opening question was based on practical suggestions issued by Nair and Riege (1995, p. 505). During the subsequent main part of the interview the revealed information usually shifted from conventional wisdom to a more personal, and more honest, description of the major issues and his or her attitudes towards them.

Table 3-2: Overall convergent interview stages

1. Introduction	Explain purpose / Small talk *Rapport not established*
2. General Questions	Unstructured part *Superficial rapport*
3. Probe Questions	Structured part *Deeper rapport*
4. Conclusion	Agreements / Disagreements *Reduced rapport*

Source: Adapted from Dick (1990, p. 50)

When the respondent showed that the topic was exhausted the unstructured part of the interview was terminated and the third stage – focusing on *probe questions* – was initiated. The initial construction of the interview questions (see Appendix B for details) was strongly guided by the tentative propositions elaborated in chapter 2 and the identified spectrum of key issues as pictured in Table 2-7. The initial version of the interview protocol was then adjusted based on findings by Behrend (2002) and Trojan (2002). The final stage of the interview was used to summarise the relevant issues in form of prioritised agreements and disagreements by asking the respondent to pick out the key points, also indicating their relative priority.

To increase the accuracy of the data collection and to allow the interviewer to be more attentive, a digital voice recording device has been used. In this context, permission was obtained from all interviewees for the digital recording of the conversations. During the interview relevant key points or remarks including a clear time code provided by the voice recorder have been documented in written form. Directly after each interview additional personal notes have been added by the interviewer, particular noting perceptions and impressions of significance that will support findings later. Each voice data file and the corresponding protocol have been stored in an electronic database to insure an effective data analysis and to allow the interviewer to *triangulate* the collected data through repetitive computer supported replaying (Patton 1990).

A major *limitation* is the fact that in the conducted interviews individuals have been asked to recall experiences regarding knowledge management in virtual project teams. However, memory biases could have affected the accuracy of reporting, as recollections may have been clouded or incomplete. This research could be improved by using a case study research design, because this type of research is particularly appropriate for pursuing a deep level of understanding of the dynamics within single settings (Eisenhardt 1989; Yin 1994). In addition the clustering and more or less intuitive categorisation of codes and concepts during the interview coding process may have disregarded possible other grouping structures, e.g. as introduced and used by Cross et al. (2002a).

The following chapter will focus on the coding and analysis of the acquired qualitative data. In his context Strauss (1987) warned that "…coding is the most difficult operation for inexperienced researcher to understand and master", therefore it has to be taken care that the final interpretation is based on a solid foundation.

3.2.2 Data analysis

In the context of this research coding formed the integral part of the data analysis. In content analysis qualitative researchers form new concepts and refine concepts that are grounded in the acquired data. It is guided by the research question(s) and the research issues and leads to new questions and new issues. It frees a researcher from entanglement in the details of the raw data and encourages higher level thinking about them. In addition it moves him or her towards theory and generalisations (Neumann 2000, p. 420). Coding is two simultaneous activities: mechanical data reduction and analytical categorisation of data into themes. In general coding systems identify one or more of four characteristics of text content: frequency, direction, intensity and space (Neumann 1994). For this research primarily the first two, namely frequency (e.g. how often something occurs) and direction (e.g. wether it is positive or negative, supporting or opposed), have been took into consideration. Strauss (1987) defined three kinds of qualitative coding, which have been used for this research:

Open coding is performed during a first pass through the collected data. To insure a sufficient quality of the raw data all voice data recordings have been replayed and the existing interview protocols have been refined and/or broadened. The interview protocols consist of three relevant parts: The in average longest section contains the general questions (1), where the respondent talked freely (unstructured) for a longer period of time. The next segment with the probe questions (2) builds the structured part of the interview and finally the summary section with its agreements and disagreements (3) focused on the respondents key perceptions. To improve the reliability of the analysis consistency checks have been done across all three parts of the interview protocols. All relevant issues in the protocols, e.g. agreements and disagreements or specific comments, have a distinct time mark, which allowed for a better comparison with corresponding index marks in the recorded voice data files.

Figure 3-2: Open coding of convergent interview raw data (Example)

01:00:30 - Disciplined communication > higher efficiency [Communication]
01:02:40 - Virtual team settings are often handled more professional than traditional organisational forms [Processes]
01:03:05 - Conversion tacit > explicit knowledge? NO / Regular reporting
01:04:10 - Measurement of knowledge? YES / Exchanged knowledge has been assessed and measured (Year 1981/ ICI London)
01:06:10 - Relevant knowledge transfer had to be filed up-front
01:10:20 - Summary
01:16:00 - Training and experience is necessary [Training / Experience]

Source: Developed for this research

Throughout the open coding process appropriate themes have been located and in a first attempt initial codes or labels assigned to condense the mass of data (see Figure 3-2). Referring to Neumann (2000, p. 422) the identified themes are at a low level of abstraction and come from the researcher's initial research question, concepts in literature, terms used by members in the investigated setting, or new thoughts stimulated by immersion in the data. At the end of the open coding process the researcher has compiled a list of initial themes, which will guide him through the subsequent stages of the content analysis.

The *axial coding* represents the "second pass" through the data where the researcher focuses more on the initial coded themes than on the data. Additional themes and new ideas may emerge during this pass and the researcher moves towards organising ideas or themes a well as identifying the axis of key concepts in the analysis. During axial coding the focus lies on causes and consequences, conditions and interactions, strategies and processes, and looks for categories or concepts that cluster together (Neumann 2000, p. 423). The researcher searches for evidence regarding core themes and builds a dense web of support in the qualitative data for them. When all major themes of the research project have been identified the third and last pass can be initiated. *Selective coding* begins after well-developed concepts are in place and the overall analysis has been grouped around several core generalisations or ideas. The researcher looks selectively for cases that illustrates themes and makes appropriate comparisons and contrasts.

The following sub-sections will describe the findings related to the three relevant interview stages namely general questions, probe question and the prioritised interviewee summaries. To strengthen the used research methodology the individual results of the different interview parts will be contrasted and assessed from a holistic point of view.

3.2.2.1 General questions (Unstructured)

The analysis of the unstructured part of the interview revealed that clear definitions and a common understanding of aspects like “knowledge management” or “virtuality” is very important to fully understand respondent statements, perceptions and beliefs. In some cases the interviewer provided appropriate definitions and explanations to insure that both interview partners are “in sync”. Another issue was the identification of more or less conventional wisdom regarding the unit of analysis obscuring important aspects below the awareness horizon of the interviewee. In this context a comparison with the later and much more structured and specific parts of the interview provided the necessary insight to adequately assess respondent statements.

The overall content analysis of the interview data identified in total nine categories or themes by which all relevant interviewee statements (see Appendix C) of the unstructured part have been grouped. Focusing on the category *“Benefits”* two respondents mentioned an increased flexibility resulting in a better work live balance. One source argued that according to his experience virtual project settings are often handled more professional, e.g. regarding processes and tools, than traditional project teams; one later interviewee supported this statement. Within the area of *“Communication”* a common language and vocabulary as well as a clear and unmistakably formulation of knowledge was considered as important. One interviewee warned that effective communication may suffer from different abstraction levels, e.g. between novices and experienced people.

An overestimated emphasis on getting tacit knowledge out of people and the conversion of tacit into explicit knowledge via project-based quality insurance processes were two statements relating to the *“Process”* category. Under the topic *“Risks”* several interesting aspects emerged: First, a company policy fostering inadequate career paths may lead to internal competition and mistrust. Second, more than three German respondents reported strong resistance from worker unions regarding the electronic storage of employee skills and the necessity for knowledge management in general. Third, two sources experienced a significant loss of knowledge related to external consultants, because no systematic knowledge transfer took place at the end of the projects; a fact which resulted in reduced contracting of appropriate external staff in these companies.

The results within the category *"Social/Cultural"* showed that the majority of the interview partners perceived a sufficient and regular personal contact with other team members as very important regarding team building, the establishment of a trustful atmosphere and the overall project success. One important aspect focusing on *"Tools/Technologies"* was the fact that in global team settings a poor network or internet bandwidth, e.g. in underdeveloped areas, resulted very often in insufficient tool performance and hindered the necessary communication and/or knowledge sharing activities. A frequency analysis (see Table 3-3) has been conducted to develop an understanding of the respondent-focused distribution of identified codes or labels in respect to the manifested categories. The analysis revealed that focusing on all three parts of each interview most issues belonged to the category "Social/Cultural" followed by "Tools/Technologies", "Processes" and "Risks". Less attention was paid to "Training/Experience" and "Structure" which ranked lowest.

Table 3-3: Frequency analysis regarding common issue categories by respondent

Respondent / **Category**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**Overall Distribution**
Benefits	1	1	2	1	1	1	1	-	-	4	4	1	8 %
Communication	1	4	2	-	-	1	1	2	2	2	2	1	9 %
Network	-	1	3	-	2	-	-	1	1	4	1	4	8 %
Processes	4	3	3	2	4	2	2	3	2	1	-	1	13 %
Risks	2	2	3	3	-	3	2	3	-	1	4	2	12 %
Social / Cultural	7	5	3	3	4	6	5	1	6	1	6	3	25 %
Structure	-	1	-	-	1	1	-	-	2	-	1	1	3 %
Tools / Technologies	1	1	5	1	-	3	1	4	3	4	5	1	14 %
Training / Experience	5	2	1	-	-	1	-	1	-	-	-	1	5 %

Source: Field data

3.2.2.2 Probe questions (Structured)

The probe questions represented the structured part of the interviews. The interviews started with a set of ten probe questions; later in the process one question was removed because no adequate respondent feedback could be obtained. Regarding the quality and homogeneity of respondent feedback it is worth to mention that later interviews (from respondent G to L) showed much better results compared to earlier ones (from respondent A to F) (see Table 3-4). This effect may be explained by the fact that later interviewees had much more practical experience in the area of knowledge management and virtual settings as well as with the interviewer learning curve.

Table 3-4: Agreements and disagreements on direct (probe) questions by respondent

Respondent / **Probe Question**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Organisational utilisation of virtual project teams (VPT) increases?	X	?	√	√	√	X	√	√	?	√	√	√
VPT are (at least) as effective as traditional project teams?	√	√	√	?	√	X	?	X	?	√	?	X
Experienced loss of knowledge in VPT?	?	?	√	√	?	?	√	√	?	X	X	√
Awareness within the [project] organisation regarding the loss of knowledge?	?	X	?	?	?	?	√	√	?	X	?	?
Implemented actions to prevent loss of knowledge?	?	?	?	?	√	?	√	?	√	√	√	√
Dedicated knowledge processes in VPT's PM framework?	X	?	?	?	?	?	X	X	√	√	√	X
Implement actions to convert tacit into explicit knowledge?	X	X	X	X	?	X	√	√	X	√	√	X
Systematic collection, storage and distribution of explicit knowledge?	X	?	?	√	?	X	X	?	√	√	√	√
Implemented actions to measure relevant knowledge?	√	X	?	X	√	X	X	X	X	X	X	√

Source: Field data

Key: √ = agreement
X = disagreement
? = unclear

The following table summarises the respondent agreements and disagreement by indicating the interviewee bias towards the different research-related aspects covered by the described direct questions (see Table 3-5). Three questions out of nine showed a clear and positive interview bias (agreement): First, most respondents felt that in their business environment the organisational usage of virtual project teams increased. Second, many interviewees experienced a loss of knowledge in VPT's and third, around 50 percent of the sample implemented processes or policies to prevent a loss of this important asset. A negative respondent bias (disagreement) was apparent regarding the conversion of tacit into explicit knowledge and well as with the measurement of knowledge. Both issues received only little attention although one interviewee argued that around 80 % of the human knowledge is not directly accessible (tacit) and another respondent put in that one cannot manage assets which are not measurable.

Table 3-5: Summary on direct (probe) questions and corresponding interviewee bias

Probe Question	**Interviewee bias** Negative	N/a or Unclear	Positive
Organisational utilisation of virtual project teams (VPT) increases?	2	2	**8**
VPT are (at least) as effective as traditional project teams?	3	4	5
Experienced loss of knowledge in VPT?	2	5	**5**
Awareness within the [project] organisation regarding the loss of knowledge?	2	**8**	2
Implemented actions to prevent loss of knowledge?	0	6	**6**
Dedicated knowledge processes in VPT's PM framework?	4	5	3
Implement actions to convert tacit into explicit knowledge?	**7**	1	4
Systematic collection, storage and distribution of explicit knowledge?	3	4	5
Implemented actions to measure relevant knowledge?	**8**	1	3

Source: Field data

3.2.2.3 Interviewee summaries

Within the final part of the interviews all respondents have been asked to pick out the key points - either in form of agreements or disagreements, also indicating their relative priority. Table 3-6 pictures the categorisation of the respondent summaries for each priority level as well as the overall distribution. What is evident is the clear focus on issues with a social or cultural character, followed by process-related and network-related aspects like communities of practice (CoP's). This result becomes even more apparent if one compares the distribution of appropriate codes in the whole interview versus the distribution of agreements or disagreement in the prioritised respondent summaries (see Figure 3-3). Besides the already mentioned dominance of the three categories one can assert that statements belonging to the category of "Benefits" or "Risks" are (nearly) not represented in the summaries. In addition issues referring to the area of "Tools/Technologies", although often addressed by respondents in the other (mostly unstructured) parts of the interviews, are obviously not as much important when an unambiguous assessment is requested.

Table 3-6: Overview of areas of categorised respondent summaries

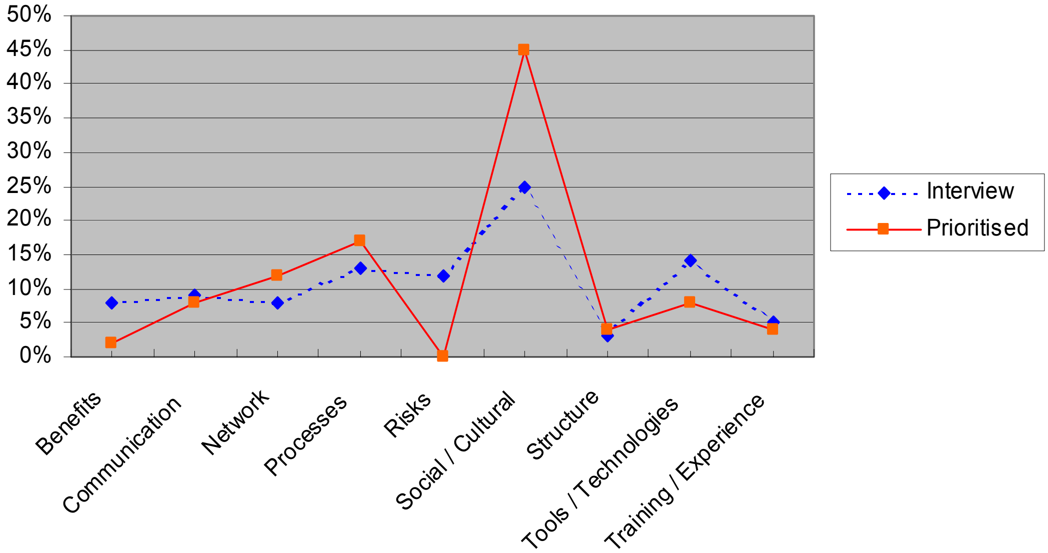
Priority Level **Category**	**1 [higher]**	**2**	**3**	**4**	**5 [lower]**	**Overall Distribution**
Benefits	1	-	-	-	-	2 %
Communication	-	-	2,5	-	1	8 %
Network	1,5	2	-	-	1,5	12 %
Processes	1	2,5	-	1	2,5	17 %

(continued)

Risks	-	-	-	-	-	0 %
Social / Cultural	5,5	3	5	3,5	1,5	45 %
Structure	-	1	-	0,5	-	4 %
Tools / Technologies	0,5	-	1,5	1	0,5	8 %
Training / Experience	0,5	-	-	1	-	4 %

Source: Field data

Figure 3-3: Comparison of category distribution: Whole Interview vs. prioritised (direct) respondent statements



Source: Field data

Summing up the key points in each category the following statements are worth mentioning: Within the dominant area of interest, hence *"Social/Cultural"*, many respondents stressed the importance of the necessary cultural alignment in the context of the appropriate team setting. Aspects like the necessary inter-cultural or inter-personal trust and a possibly existing competitive pressure, either relating to different involved organisations or even between team members of one company, have to be balanced and controlled. Almost all interview partners argued that a pure virtual setting is not desirable and urged the need for regular social contacts, e.g. via face-to-face meetings. When focusing on *"Processes"* it was evident that clear but simple processes have to be defined and put into practice. In this context definite project-related as well as knowledge-related goals, roles and responsibilities have to be set up and communicated.

Several respondents judged the collection and conversion of tacit into explicit knowledge as very limited, especially in a stressful project atmosphere. Two interviewees argued that the appropriate project-focused quality insurance processes and/or systems are better suited to store emerged knowledge. From a *network* theory perspective several interviewees emphasised the need for social capable team players building effective human relationships and networks thus establishing the basic framework for knowledge exchange. In this context the individual capability to *communicate* in a clear and brief yet comprehensive manner is essential. From a holistic perspective it is important to maintain the "big picture" and to exercise leadership focusing on spirit and purpose. The interview findings confirmed appropriate literature sources which state the continuously increasing use of virtual project teams. Although some interviewees mentioned the lack of appropriate project processes capable of handling and controlling the often complex virtual conditions, it is doubtful whether these processes are really missing, because already available project frameworks and concepts are often unknown or not properly implemented and used.

3.3 Identification of relevant determinants

Based on the discussion of the findings of this first exploratory stage several new ideas emerged and additional dimensions could be identified which led to a revised and more focused literature review. This enhanced theoretical basis will now be used to refine the prior tentative research issues and to design a comprehensive research framework able to provide significant insight targeting the following research question:

> *How do socio-cultural enabling conditions and network-related factors influence knowledge creation and exchange in virtual project teams?*

Social and cultural aspects ranked highest in the frequency analysis (see Figure 3-3) and prioritised by most interviewees as often not actively managed within real live project settings. Especially within the fluid and complex virtual work environments this ignorance can have severe consequences. Focusing on *trust* as one of the most important enablers in virtual teaming (see chapter 2.6.1 and 3.3) a two-way interaction between trust and cooperation can be identified: trust lubricates cooperation, and cooperation itself breeds trust. This may lead to the development, over time, of generalised norms of cooperation, which increase yet further the willingness to engage in social [and knowledge] exchange (Putnam 1993). In this respect, collective trust may become a potent form of "expectational asset" (Knez & Camerer 1994) that team members can rely on more generally to help solve problems of cooperation and coordination (Kramer et al. 1996). Given this line of argumentation and focusing primarily on literature review chapters 2.6.3 and 2.7.4 the following research issue will be investigated:

RI 1: How do the level and type of trust within a virtual project team affect the creation and exchange of knowledge?

The importance of a *shared language and a common vocabulary* could be even certified during the conducted convergent interviews, where some misunderstandings regarding key terms and definitions showed up and had to be resolved. In this context De Long and Seemann (2000) argue that given the ambiguity within the area of knowledge management, groups will quickly define the subject in ways that give them political advantage; an issue which puts additional pressure on the implementation of effective knowledge processes within a virtual team environment. Referring to the requested clear and unmistakably formulation of knowledge one has to remember that knowledge is always context sensitive and that the knowledge worker's level of expertise (the level of abstraction) as well as the cost of codification have to be managed accordingly (Snowden 2002). In this context and referring to chapter 2.3.1 and 2.4 of the literature review the subsequent research issue will be examined in detail:

RI 2: How can a shared language and a common vocabulary impact knowledge management in virtual project teams?

Focusing on the tacit–explicit knowledge debate the use of organisational *formal and informal networks* as an important influencing factor in supporting a trusted team environment and ensuring the effective creation and exchange of knowledge becomes more and more important. These social networks are omnipresent, but difficult to identify and to manage. Studies by Nissen et al. (2000b) showed that knowledge captured through informal mechanisms is often richer and more important to the organisation than that stored through formal mechanisms. Such knowledge, which is often created outside the realm of institutionally mandated methods and procedures, can dissipate from organisational memory because of such factors as corporate reorganisation, turnover in personnel, and changes in technology. Synthesising the interview findings and chapters 2.3 and 2.5.2 of the literature review the following issue will provide useful evidence regarding the research question:

RI 3: To what extent do informal networks influence the knowledge creation and exchange in virtual project teams?

Building effective human relationships and networks in business environments is probably the major prerequisite for sustainable knowledge generation and exchange. In this context chapter 2.3 as well as chapter 2.4.5 of the literature review provides clear evidence that theses processes are heavily dependent in *boundary* crossing activities. Without boundary-crossing, team members could focus simply on their own disciplinary work without due regard for or collaboration with other disciplines, locations and/or project partners. The following research issue will investigate these important boundary-spanning processes in virtual project settings in more detail:

RI 4: How do boundaries support or hinder knowledge creation and exchange?

Very often involved project parties have different perspectives of what explicit and tacit knowledge should be shared and to what extent; necessary policies and processes are not yet developed, insufficient and/or not adequately implemented. This aspect is paired with an unawareness of existing knowledge ‘potential’ and – sometimes even more critical - knowledge leaks as well as related (uncontrolled) knowledge diffusion processes. This notion is supported by several interviewees, who experienced – despite a comprehensive media coverage targeting the importance of intellectual assets - knowledge losses involving external parties, e.g. consultants or project partners, hence the necessary *risk* awareness is still missing. This discovery in combination with chapter 2.5.2 and 2.7.5 of the literature review urged the clarification of the subsequent research issue:

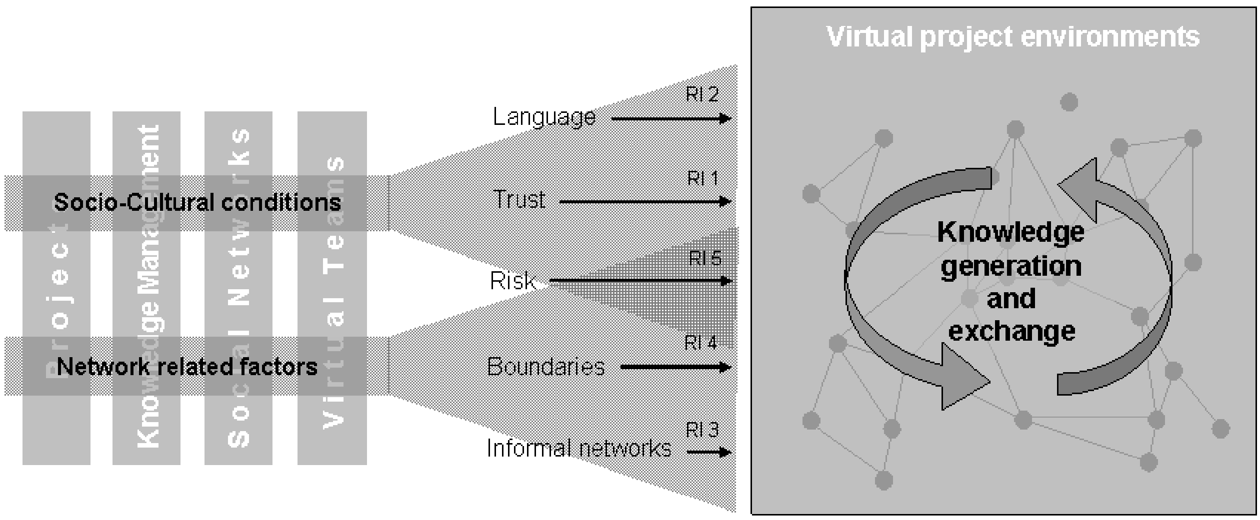
RI 5: What are the risks associated with limited awareness regarding the quality of the existing knowledge repository and uncontrolled knowledge diffusion processes in virtual environments?

Having developed and discussed the five focal aspects targeting the examination and answer of the raised research question, the next section will present the corresponding analytical model.

3.4 Presentation of analytical model

The analytical model is a very important part of this dissertation because it integrates the theoretical basis from which the research issues have been developed. It provides a united view by linking the research problem, the parent / immediate disciplines and the research issues. As depicted in Figure 3-4 the aim of this dissertation is to investigate knowledge management processes in virtual project settings, which are viewed as boundary spanning social (knowledge-) networks. The identification and comprehensive study of four parent disciplines namely projects, knowledge management, social network and virtual teams revealed the significance of socio-cultural conditions as well as of network-related factors and processes. It came apparent that both areas represent different dimensions of the phenomenon under investigation and that both are interrelated. In this context, using a convergent interview technique five research issues focusing on trust, language, informal networks, boundaries and risk could be finally identified, all having the potential of providing relevant insight regarding the complex and heterogenous research problem.

Figure 3-4: Presentation of Analytical Model



Source: Developed for this research

3.5 Summary

This first exploratory stage of the research had the purpose to develop a good grasp of the actual situation regarding knowledge management in virtual project teams. Important facts and relevant concerns as well as further ideas and dimensions could be identified by conducting and analysing twelve convergent interviews with practitioners as well as academics from different professions and an international working background. To insure a sufficient reliability and rigidity of the data collection the appropriate documentation, coding and analysing processes have been designed accordingly. The use of digital voice recording and the electronic storage of voice data files and corresponding interview protocols allowed for a better triangulation of the research data.

The results showed a clear focus on issues with a social or cultural character, followed by process-related and network-related aspects like informal networks. Most interviewees emphasised the need for social capable team players building effective human relationships and networks thus establishing the basic framework for knowledge exchange. Respondents stressed the necessary existence of trust as one of the most important enablers for cooperation in virtual teaming as well as the availability of a shared language and a common vocabulary within the virtual project team, because knowledge is always context sensitive and different knowledge worker’s level of expertise (level of abstraction) have to be synchronised. The analysis and interpretation of the interview findings together with a corresponding literature research formed the basis for the refinement of the preliminary research question and corresponding research issues. Next, the developed research methodology will be explained and discussed.

4 RESEARCH METHODOLOGY

4.1 Introduction

"And between your knowledge and your understanding,
there is a secret path."
[Kahil Gibran]

The previous chapters reviewed the extant literature as well as the background of the research problem and refined the preliminary research question / issues by conducting and analysing 12 convergent interviews with global business and academic experts. This chapter will discuss and justify the research design and the methodology used to collect the field data to address the identified research issues. In addition the preparation and execution of the necessary pilot study and the subsequent refinement of the research methodology will be described.

Based on its explanatory nature this study of knowledge management in virtual work environments operates within the scientific paradigm of critical realism. A multi-method approach utilising case studies and social network analysis (SNA) has been used. This chapter starts with the justification of the selected research paradigm and the developed integrated research methodology to address the identified research problem. Next, the criteria for judging the research design involving the validity and reliability of the chosen integrated approach are discussed. Then, further details regarding the chosen research design issues like the role of prior theory and the criteria for selecting the number and type of cases are explained. Building on that the process of data collection as well as the pilot case study are discussed. This is followed by a case study and survey analysis section. Finally, limitations to the study and ethical considerations are addressed.

4.2 Justification for the research paradigm

Kuhn (1996) defined "paradigm" in quite a number of ways, emphasising the importance of both content and function. The contribution of knowledge to science loosely involves a new scientific theory, while the paradigm functions as a focal point for commitment and consensus of the scientific community on what constitutes normal science. According to Guba and Lincoln (1994) a paradigm is a basic set of beliefs how the world works and what the individuals' place in it is. These are the fundamental assumptions that researchers bring to their work and cause them to approach inquiry or argument in particular ways (Toma 1997).

In order to justify the selection of the research paradigm for this study, the nature as well as the differences between the four paradigms proposed by Guba and Lincoln (1994) was taken into consideration. Table 4-1 compares the four paradigms along the dimensions of ontology, epistemology and methodology.

Table 4-1: Scientific research paradigms

	Paradigm			
Item	Positivism	Post-Positivism	Critical Theory	Constructivism
Ontology	naïve realism: reality is real and apprehensible	critical realism: reality is 'real' but only imperfectly and probabilistically apprehensible; triangulation from many sources is required	historical realism: virtual realty shaped by social, political, cultural, economic, ethnic, and gender values; crystallised over time	relativism: local ad specific constructed realities
Epistemology	dualist/objectivist: findings true	modified dualist/ objectivist: findings probably true	transactional /subjecstivistic; value-mediated findings	transactional /subjectivistic; created findings
Methodology	experiments/ surveys: verification of hypotheses: chiefly quantitative methods	case studies/ convergent interviewing: triangulation, interpretation of research issues by qualitative and quantitative methods	action research	in-depth interviews, participant observation

Source: Based on Guba & Lincoln (1994), McPhail & Perry (2002)

Guba and Lincoln (1994) employ Kuhn's concept of paradigms as their foundation and suggest that researchers adopt assumptions in the following three areas: Ontology is the fundamental assumptions made about the form and nature of reality. It is concerned with the question of what aspects of the world can be researched. Epistemology pertains to the relationship between reality and the researcher (Guba & Lincoln 1994) and the methodology relates to the process of finding out about reality; thus methodology outline the appropriate research tools or techniques for conducting research (McPhail & Perry 2002). The four paradigms will now be discussed in more detail and their application to this research project about knowledge management in virtual teams will be discussed.

Positivism assumes an apprehendable reality, which is driven by immutable natural laws and mechanisms. The investigator and the investigated 'object' are assumed to be independent entities, and the investigator is capable of studying the object without influencing it or being influenced by it. The basic posture of the paradigm is argued to be both reductionist and deterministic (Hesse 1989). Questions and/or hypotheses are developed in propositional form and tested empirically, taking care that possible confounding conditions are thoroughly controlled (Guba & Lincoln 1994).

Though the positivistic approach is the dominant paradigm of much scientific research, like experiments or surveys, it is not suitable for this research for two reasons. First, positivist researchers separate themselves from the world, thus the research problem, (Trochim 2003) and therefore are not able to interact with all the stakeholders as deeply and subjectively as is required to fully understand the complex issue at hand (Perry, Riege & Brown 1999). This research tries to investigate and understand socio-cultural conditions and network-related processes in virtual team environments and depends primarily on the holistic combination of individual subjective realities regarding the issues at hand. Second, there is little prior theory in the field of knowledge management in virtual project teams. That is, theory-testing is impossible, because of little and insufficient prior research which hasn't produced the necessary theory and constructs (Perry 1998).

The paradigm of *critical theory* seeks to critique and change social, political, economic, ethnic and gender values over a long period of time (Perry, Riege & Brown 1999). The assumptions used by critical theorists are subjective concepts, which are developed from social ad economic phenomenon (see Table 4-1). Researchers using this paradigm assume that knowledge involves a series of comprehensive social realities that can be transformed over time (Guba & Lincoln 1994).

The critical theory paradigm is not appropriate for this study because the researcher did not aim to be a "transformative intellectual" who influences perceived realities of people on their historical and structural insights over a period of time (Guba & Lincoln 1994). Rather it is tried to understand how socio-cultural enabling conditions and network-related processes influence the effective knowledge generation and transfer within the investigated research setting instead of changing the individual perceptions of the involved stakeholders regarding these aspects.

Constructivism holds that truth is a particular belief system held in a particular context (Healy & Perry 2000). Like critical theory, constructivism inquires about the ideologies and values that lie behind a finding so that reality actually consists of “multiple realities” that people have in their mind. Researching this constructed reality depends on interactions between interviewer and respondent, that is, the researcher has to be a “passionate participant” during the course of investigation (Guba & Lincoln 1994; Lincoln 1991).

Nevertheless, constructivism is not suitable for marketing and business research because the approach excludes concerns about the important, and clearly “real”, economic and technical dimensions of business (Hunt 1991). Thus this paradigm is not appropriate for this study because the complex socio-cultural conditions and network-related processes not only depend on the involved team members beliefs and experiences, but also on highly dynamic relational aspects and other diverse external influences.

The description and discussion of the mentioned three paradigms showed that these approaches are not suitable for this research. The critical realism paradigm is considered the most appropriate paradigm as it has elements of both positivism and constructivism and will be discussed next.

Post-positivism or *critical realism* paradigm views reality as existent but only imperfectly apprehendable because of basically flawed human intellectual mechanisms and the fundamentally intractable nature of phenomena (Guba & Lincoln 1994). In other words, perception is not reality as constructivists and critical theorists might aver; instead, a perception for realists is a window on to reality through which a picture of reality can be triangulated with other perceptions (Perry, Riege & Brown 1999). The discovery of observable and non-observable structures and mechanisms that underlie events and experiences is the goal of realism research (Tsoukas 1989). Given the complexity of the social science world where this study is located, the knowledge that realism researchers obtain “is considered real but fallible” (Wollin 1995, p. 80). Considering the nature of this research, several aspects influenced the selection of this paradigm.

First, the research requires inductive theory building because deduction from already existing principles of a “paradigm” is likely to be difficult where accepted principles and constructs have not been established or are clearly inadequate (Perry 1998; Behrend 2002). Second, this inductive approach not only has the potential to generate validated theories of knowledge management phenomena but also allow the key variables to be studied in a broader perspective which may give rise to other important variables (Chew 2001). Third, the phenomena under investigation, knowledge management in virtual work environments, occurs in a very dynamic and complex boundary-spanning environment, which calls for a research approach attempting to grasp as much as possible of the social and cultural context in which project teams operate (Yin 2003). Fourth, while a certain level of objectivity is required from the researcher, ensured through a rigorous and well documented methodology, he takes an active and subjective role, being deeply involved in the study and the topic (Perry, Riege & Brown 1999).

Having justified the use of the critical realism paradigm for this research the next section focuses on the methodology and explains the advantage of a combined approach using case study methodology and social network analysis.

4.3 Justification of the developed multi-method exploratory approach

The primary research approach for this study has qualitative character and will make use of the *inductive theory-building case study methodology*. This methodology is well suited to ensure the necessary contextual understanding and the achievement of empathetic objectives through a direct, firsthand, more or less intimidate analysis of the research setting. Nevertheless due to the challenging area of research (dynamic social processes within a virtual environment), weaknesses of the case study methodology (see Table 4-2) and specific data collection procedures (see section 4.6), the qualitative methodology will be supplemented by an *embedded quantitative survey* (Social Network Analysis). Referring to Table 4-2 it is observed that many of the strengths of one method compensate for the weakness in the other and that the overall quality of the research will be enhanced.

Table 4-2: Relative strength of case study and survey methods

	Case study	**Survey**
Controllability	Low	Medium
Deductibility	Low	Medium
Repeatability	Low	Medium
Generalisability	Low	High
Discoverability (explorability)	High	Medium
Representability (potential model complexity)	High	Medium

Source: Based on Gable (1994, p.114)

In this context Gable (1994) suggests that a carefully chosen mix of methods be combined for a single research project. According to the author the combination should be designed to meet the needs of discovery and verification/falsification, plus the need to understand actor's meanings and intentions while measuring 'objective' and quantitative distributions of outcomes. Attewell and Rule (1991, p. 297) highlight the complementary between survey and fieldwork approaches and Danziger and Kremer (1991, p. 367) point out that survey research and fieldwork have always been alternative rather than competing sources of evidence and ideas.

Next, the use of the case study methodology for this research will be justified and then the supportive function of the Social Network Analysis (SNA) will be explained and defended. First, the extent of theory development relevant to this research is considered to be relatively low and inconsistent, thus the traditional approach would be to first build theory through primarily qualitative research and then verify theory through quantitative methodologies (Chew 2001). According to Eisenhardt (1989) case study methodology is a suitable strategy for new and under-developed research areas like knowledge management in virtual project teams.

Second, this study involves a more exploratory than explanatory approach, with an attempt to develop and define relevant issues related to virtual knowledge management processes and to enable a proper understanding of influencing factors. Given the absence of control and the focus on contemporary issues (discussed in detail later) the primarily 'how' and 'why' questions in this exploratory research are best addressed by the case study methodology (see Table 4-3). The same table shows that a survey strategy, with its broader and partly deeper scope of research questions represents an ideal supplement under the described circumstances.

Table 4-3: Selection of appropriate research methodology

Strategy	**Form of research question**	**Requires control over behavioural events?**	**Focus on contemporary events?**
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival analysis	Who, what, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

Source: Based on Yin (2003, p.5)

Third, case studies are best suited for research questions where the researcher attempts to understand the complex contemporary events in situations over which the researcher has little or no control (Chew 2001). As the researcher will have neither control over the behaviour and dynamics of the people and teams involved nor over the boundary-spanning organisational situations, case study methodology seems appropriate (Yin 2003).

Finally, this research investigates contemporary phenomena as the research focuses on the knowledge generation and transfer in virtual work environments, an issue with little to no historic precedents. Combined with the earlier criteria, case study methodology is seen as the best approach for this exploratory research. But still, a more quantitative methodology can add significant value to the primarily qualitative data collection and the subsequent interpretation of findings.

Social Network Analysis (SNA) belongs to a group of quantitative survey methods which emphasise the collection of data from a relative large number (compared with the case study approach) of individuals and the analysis of the data using statistical data. Vidich and Shapiro (1955, p. 31) observe that, “Without the survey data, the observer could only make reasonable guesses about his area of ignorance in he effort to reduce bias”. And Jick (1983, p. 138) suggests that survey research may also contribute to greater confidence in the generalisability of the results.

SNA methodologies provides a rich and systematic means of assessing informal networks by mapping and analysing relationships among individuals, teams or organisations (Wasserman & Faust 1999). Within the complex and fast-changing project environments, where this research is situated, it is very challenging for individuals (and the researcher) to understand the networks and corresponding processes around them. In this context the potential for inaccurate perceptions is increased by the transition into a world of virtual work and telecommuting (Cross et al. 2001). SNA can provide the researcher with an X-ray of the way knowledge is generated and transferred or not in these informal networks.

Therefore the overall data collection strategy for this study starts with a broader qualitative ‘macro-level’ analysis, utilising a case study methodology, where a well chosen mix of generally three individuals in each setting will be interviewed to gain the necessary insights for theory development. Attewell and Rule (1991, p. 314) suggest that it makes sense to do fieldwork first: “Getting close to the phenomenon – gathering insights or discoveries about causal links, motivations, reasons why things happened – should precede verification by more objective techniques, such as surveys”. Therefore, in a second step, a more focused quantitative survey-based ‘micro-level’ analysis using SNA methodology will be used to produce a blueprint of the actual case study setting, e.g. a virtual project team. In contrast to Gable (1994), who build a priori conceptual model based on the findings from case study research and then used a survey approach to refine and test the model, this study utilises a slightly different strategy. In this specific research context both methodologies will be used in one individual case study setting more or less in parallel, thus maximising process and financial efficiency on one side, but reducing survey quality and generalisability on the other side (see section 4.9 for more details).

This section has shown that through the combination of the discussed methods the robustness of results can be increased; findings can be strengthened though cross-validation achieved when the different kinds and sources of data converge and are found to be congruent, or when explanation is developed to account for differences (Kaplan & Duchon 1988). The next section will now focus on the evaluation of the quality of the developed multi-method research approach.

4.4 Criteria for judging the quality of the research design

Because a paradigm is a world view, the quality of scientific research done within a specific paradigm has to be judged by its own paradigm’s terms (Healy & Perry 2000). The following two sections will evaluate the aspect of research design quality from the different methodological perspectives, thus the qualitative case study technique and the quantitative, survey-based, Social Network Analysis (SNA).

4.4.1 Case study perspective

Based on its similar nature it seems appropriate for this study to build on Teale’s (1999) criteria catalogue (see Table 4-4), which is in essence a paradigm-focused extension of Yin’s (2003) four-stage design test, thus construct validity, internal and external validity and reliability.

Table 4-4: Qualitative criteria for case study research design evaluation

Criterion	Methodical tactics	Phase of research in which tactic occurs
Ontology of realism	• 'External' socio-cultural phenomenon	General research focus
Contingent validity	• Theoretical and literal replication • Case context description	Research design Research design
Construct validity	• Use prior theory • Use multiple sources of evidence (Multiple perceptions) • Establish chain of evidence • Have key informants review draft case study report	Research design Data collection Data collection Data analysis and report writing
Internal validity	• Do pattern-matching • Do explanation-building • Address rival explanations	Data analysis Data analysis Data analysis
External validity (Analytical generalisation)	• Use Replication logic in multiple case studies	Research design
Reliability (Methodological trustworthiness)	• Use a systematic data collection methodology (Case study protocol) • Develop case study database	Data collection Data collection

Source: Developed from Yin (2003, p. 34), Healy & Perry (2000) and Teale (1999)

The ***ontology of realism*** assumes that the research is dealing with complex social phenomena outside people's minds involving reflective people (Teale 1999). This study deals with knowledge management in virtual project teams, hence how knowledge is generated and shared, therefore issues and processes with a clear 'external' socio-cultural background. The next criterion for realism research is '***contingent validity'***, that is, validity about generative mechanisms and the contexts that make them contingent. This criterion is meet by concentrating on why things happened and not just describing them, using theoretical and literal replication to ensure that information will be obtained from appropriate, information-rich sources (Healy & Perry 2000; Patton 1990; Yin 2003), and describing the context of the cases like the size and composition of the virtual project teams, dates of the interviews and team roles of the interviewees.

Construct validity is concerned with the development of correct operational measures for the concepts under review (Emory & Cooper 1991; Yin 2003). The operationalisation of concepts in this research is based on concepts identified in the literature review as well as by means of the conducted twelve convergent interviews with international managers and experts. Because realism relies on multiple perceptions about a single reality, several data sources have to be triangulated and the applied data collecting procedure has to be structured and well documented (Healy & Perry 2000). Moreover, the analysis and interpretation of the corresponding results should be examined by appropriate key informants (see Table 4-4). These three techniques will now be explained in more detail:

First, triangulation will be achieved by collecting data from *multiple sources* like convergent and in-depth interviews, paper-based and web-based documentation, surveys (SNA) and field observations. Within the main data collection phase between three and five interviews will be conducted in each case to capture information-rich perceptions of representatively team members within the investigated virtual project teams. Details of the interviews and other sources of evidence are discussed in section 4.5 of this document.

Second, construct validity during the data collection phase can be enhanced by establishing a *chain of evidence*. All data will be systematically recorded, with sources of data carefully referenced during data analysis to achieve a high quality of research (Yin 2003). A case study protocol including an interview protocol as well as an SNA (survey) questionnaire have been designed (see Appendices D and E) to attain a structured approach in the course of exploring the research issues, thus ensuring a smooth sequence of questioning and proper identification of data collected. Details regarding the structure and content of the two protocols and the questionnaire are discussed in section 4.6.2 and section 4.6.3.

Third, the draft case analysis will be *reviewed by key informants* of the individual case during the data analysis and report writing phase. Utilising this strategy, any inconsistency or ambiguity could be detected and clarified thus enhancing the construct validity and overall quality of this research (Miles & Huberman 1994; Yin 2003).

Internal validity relates to the correctness and reliability of the study results (Yin 2003) and describes the ‘truth value’ and credibility of study results (Miles & Huberman 1994). In qualitative research, cause-and-effect internal validity is normally not a major concern because qualitative research tries to identify what are the variables involved in a phenomenon and leaves the cause-and-effect relationships between the variables to later quantitative research (Zikmund 2000; Yin 2003). However, based on the selected qualitative approach, internal validity is still necessary to minimise ambiguity and contradiction.

While it is difficult to provide clear tactics to increase internal validity, Yin (2003) recommends pattern matching and addressing rival explanations before drawing conclusions from inferences. Regarding the chosen case study methodology internal validity will be achieved through a constant effort of within-case analysis, cross-case analysis and cross-cluster analysis to establish linkages between data collected in the form of observations, quotes, inferences, explanations and meanings to ensure that conclusions drawn have been systematically explored (Miles & Huberman 1994; Perry 1998; Yin 2003).

External validity is concerned with the generalisability of the cause-and-effect relationships of the research findings (Yin 2003). Given the complexity of realism's world, realism research must be primarily theory-building using analytical generalisation, rather than the testing of the applicability of a theory to a population via statistical generalisation, which is the primary concern of positivism (Healy & Perry 2000; Miles & Huberman 1994). In case study research, analytical generalisation is achieved through replication logic utilising multiple cases. Further, external validity is also attained through comparing the research evidence with extant literature (Eisenhardt 1989).

In this research, multiple case studies (see section 4.4) will be used to achieve analytical generalisation by means of applying the literal replication logic. A comparison of the research findings to the extant literature will further facilitate the necessary analytical generalisations in this study (Miles & Huberman 1994; Yin 2003).

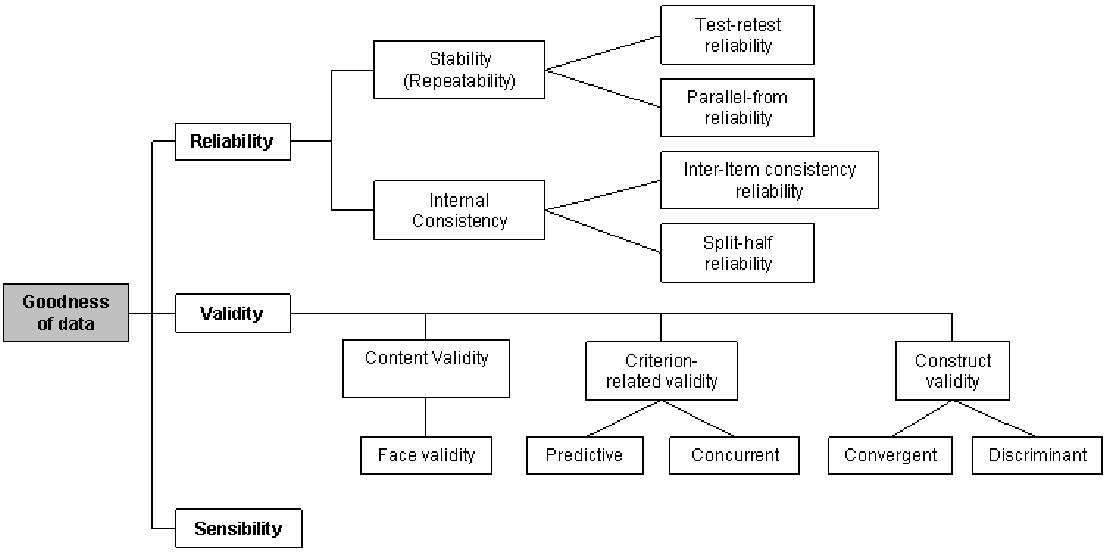
Finally, ***reliability***, or methodological trustworthiness, describes the extent that the study would produce similar results if repeated (Emory & Cooper 1991; Zikmund 2000). High reliability suggests that similar findings were obtained if the data collection techniques and procedures remain constant throughout the repeated research (Yin 2003). To overcome and minimise the inconsistency and problems regarding the reliability of the case study research findings, Yin (2003) recommended the following strategy: develop a case study protocol in the research design phase and use this protocol to collect data and develop a case database during the data collection phase (see Table 4-4).

For the case study part of this research, three reliability tests will be used: First, an interview has been developed in the research design phase and tested in two pilot case interviews before it was used in the main data collection, as discussed in section 4.7. Second, a clear and systematic data collection protocol was prepared to outline the whole process of data collection and the procedures and requirements to be followed (see section 4.6.2). Third, a case study database will be set up and kept up to date for the researcher to access the data if necessary (Yin 2003).

4.4.2 Social Network Analysis (Survey) perspective

The primary goal of the Social Network Analysis within the context of this study is to visualise the informal (knowledge) networks and related processes within the investigated virtual project team. In contrast to common quantitative research designs, where [random] sampling is a major determinant for methodological quality (Sproull 1995), this primarily qualitative research approach uses a clearly defined replication logic based on purposeful sampling for selection of the main data sources, hence case study settings (see section 4.5.3). Referring to Figure 4-1, this section will describe and discuss an adapted set of criteria to sufficiently address the two main groups of criteria, namely validity and reliability (McPhail 2002) as well as sensitivity, which refers to a quantitative instrument's ability to accurately measure variability in responses (Zikmund 2000).

Figure 4-1: Criteria for Good Measurement of quantitative research methodologies



Source: Based on Sekaran (2000) and Zikmund (2000)

First, several types of ***validity*** tests will be addressed. To ensure *content validity* and *face validity*, hence is the full content of a definition represented in the measure and does the measure really capture the concept, expert judgement will be sought. The major development stages of this research have been discussed with knowledgeable informants to get a regular professional feedback and additional support if needed. *Concurrent validity* and *predictive validity* are both not relevant for this study. The first one, because it assesses the correlation with already validated measures (Sproull 1995), which are not available for the area of research and the second one, because its focus lies on future events that are logically related to a construct (McPhail 2002), which doesn't fit with the chosen time basis for this research.

The last type in this group, *construct validity*, determines the degree to which a measure correlates or correlates not with other measures of the same thing (*convergent validity* and *discriminant validity* respectively). To fulfil this criterium sufficiently, input from codified qualitative data will be used to assess mutual relations. In addition, to ensure that the measure with multiple items operates in a consistent manner, the appropriate SNA questionnaire will be designed in accordance with already proven survey structures and contents (see section 4.6.3.2 and appendix E for details).

After determining the validity of the survey instrument, it is necessary to assess its ***reliability***. Focusing on repeatability both 'standard' criteria, hence test-retest reliability and parallel-form reliability are not suitable for the chosen multi-method research approach. The basic problem with straight *test-retest reliability* is the fact that respondents will tend to reply to an item the same way in a second survey as they did in the first (Churchill 1979). Moreover, social phenomena can not be assumed to remain in stasis over any but the shortest spans of time (Wassermann & Faust 1999). The second one, thus *parallel-form reliability* is just not adequate because no two comparable set of measures tapping the same construct will be used within this study (McPhail 2002). Focusing on *internal consistency*, coefficient alpha is the basic statistic for determining the reliability of a measure. Churchill (1979) notes that this statistic does not adequately estimate errors caused by external factors such as differences in testing situations and respondents over time. Therefore additional data from the case study interviews will be used to enhance the overall reliability coefficient.

Sensitivity refers to an instrument's ability to accurately measure variability in responses (McPhail 2002). Because the sensitivity of a scale is directly linked with range of possible scores, a five point Likert-type scale will be used within the appropriate survey instrument to capture respondent's perceptions adequately.

Pointing to Wassermann and Faust (1999, p. 57) several studies conclude that about half of what people report about their own interactions is incorrect in one way or another. On the other side the authors argue that particular interactions are not of primary concern, but the 'true' structure of the network, based on relatively stable patterns of interaction.

In summary, the following general principles have been taken into account to ensure a sufficient quality of the research design without forgetting the inherent geographical and financial constraints of such studies (Neumann 2000, p. 166):

- Constructs/concepts have been clearly conceptualised
- A high level of measurement will be established
- Multiple indicators will be used to measure one aspect
- Pilot tests and replication will be used

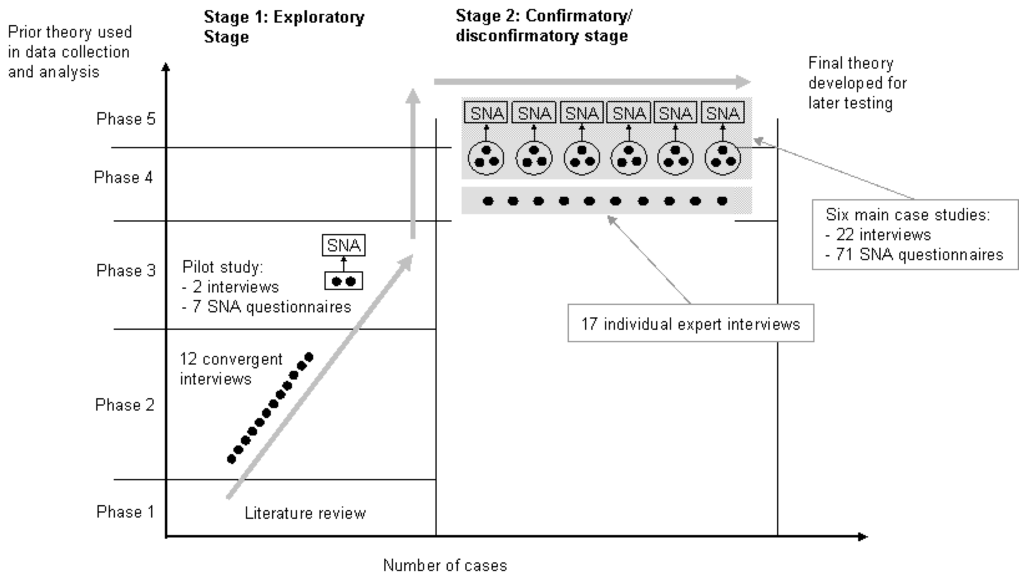
4.5 Research design details

The next five sections will now further describe and discuss relevant aspects of the developed multi-method research design, like the process of theory building, selection criteria and replication logic as well as number and sources of cases. The final section presents the overall workflow of the integrated approach, starting with the first definition of the research context and ending with the interpretation of study findings.

4.5.1 The role of prior theory for this integrated research approach

Previously it was argued that critical realism is the appropriate paradigm for this research due to the lack of established theory within the literature about knowledge management in virtual project environments. Despite the inductive nature of this research, some prior theory can have a pivotal function in the design and analysis of this multi-method study (Perry, Riege & Brown 1999). Pure induction might prevent the researcher from benefiting from existing theory, just as pure deduction might prevent the development of new and useful theory. Therefore Parkhe (1993, p. 252 and p. 256) claims that 'both extremes are untenable and unnecessary' and that the process of ongoing theory advancement requires 'continuous interplay' between the two. In line with this argumentation this study applied a balanced research design between induction (exploratory) and deduction (confirmatory), as depicted in Figure 4-2, which will be discussed next.

Figure 4-2: Stages of theory building for this research



Source: Developed from Perry (1998)

This research was conducted in two stages. The first exploratory stage covers three phases, whereas the second confirmatory/disconfirmatory stage includes two phases. The exploratory stage began with a comprehensive literature review, followed by twelve convergent interviews with practitioners as well as academics focusing on knowledge management in virtual, boundary-spanning project teams. The objective of these two phases (Phases 1 and 2 in Figure 4-2) was to develop some prior theory to help to identify the research problem for the subsequent formulation of the research's theoretical framework, e.g. the research question and the corresponding research issues (Nair & Riege 1995). The overall data collection strategy including the two collection instruments, namely the case study interview protocol and the SNA questionnaire, has been tested in a pilot setting, to allow for a better refinement of the data collection plans and procedures before the start of the main data collection in stage two (Eisenhardt 1989; Yin 2003). The pilot study itself (Phase 3 in Figure 4-2) comprised two interviews within one project team and a Social Network Analysis (SNA) with seven respondents to test the visualisation of a team's informal (knowledge) structure.

The main data collection within the confirmatory/disconfirmatory stage has been implemented using two distinct phases. A total of six different case study settings with three interviews each build the first phase (Phase 4 in Figure 4-2) utilising the tested interview protocol to collect subjective data from the interviewees regarding the identified research issues. The last phase (Phase 5 in Figure 4-2) focuses on the accumulation of more objective data applying the survey-based SNA to supplement the previous qualitative data collection within the appropriate case study setting. The two mentioned data sources will then be analysed (see chapter 4.8 for details), interpreted and the final theory developed for later more extensive statistical testing. In addition 17 individual depth interviews with an interdisciplinary mix of knowledgeable business professionals and academic sources have been carried out to supplement the case data.

In summary, this two-stage theory-building approach is consistent with the critical realism paradigm's search for capabilities rather than regularities as well as for analytic generalisation rather than statistical generalisation (Tsoukas 1989 as cited in Perry 1998). The use of prior theory in this research facilitated the development of an appropriate theoretical framework and provided focus and direction to the data collection process.

4.5.2 Criteria for selecting multiple case studies

In section 4.3 the multi-method research approach for this study has been described and justified. This section discusses the number and size of the underlying case study settings.

A multiple case study rather than a single case design approach will be used for this study since a multiple case design has many advantages (Miles & Huberman 1994; Yin 2003). In detail, the multiple case study approach was chosen for the following main reasons:

- A full variety of evidence is provided, which includes interviews, direct field observations, documents and survey's (Chew 2001).
- It involves a methodologically rigorous approach based on replication logic (Chew 2001; Yin 2003).
- Multiple case design provides triangulation of evidence, data sources and research methods for more rigorous research (Eisenhardt 1989; Yin 2003).
- Multiple case design has the capacity to handle the complex phenomena under investigation (Eisenhardt 1989; Patton 1990; Yin 2003).

- Furthermore multiple case design can be used for theory generalisation (Eisenhardt 1989; Patton 1990) as well as for theory testing through literal and theoretical replication (Eisenhardt 1989; Bonoma 1985).

In contrast, a single case study approach is appropriate only when the following three criteria are met: a critical case, a unique/extreme case or a revelatory case in which it is possible to observe phenomena previously inaccessible to scientific investigation (Chew 2001; Yin 2003). In this research no single case is able to satisfy these criteria.

In summary, a multiple case study approach will be used in this research because it has several advantages compared to a single case study design. In particular, the triangulation of data using multiple sources of evidence enables replication for theory generalisation. The next section will discuss the applied forms of replication, thus literal and theoretical replication.

4.5.3 Replication logic for multiple case studies

Yin (2003, p. 45-50) advises that “multiple-cases” should be regarded as “multiple experiments” and not “multiple respondents in a survey”, and so replication logic and not sampling logic should be used in multiple-case studies, like this one. In order to achieve this theoretical and literal replication, the cases for this study have been selected for their specific relevance to this research. Referring to Stake (1994) as well as Yin (2003), a guarded choice of each case should be made so that it either predicts similar results for predictable reasons (literal replication), or produces contrary results for predictable reasons (theoretical replication). For both issues, information richness of the cases remains fundamental to the selection of individual research settings (Patton 1990). In contrast to Perry (1998), who emphasises the importance of theoretical replication as the key to the selection as well as analysis of case study data, this research approach seeks a more balanced position to ensure the creation of a broader data pool as basis for a later as representative as possible cross-case analysis.

To attain theoretical and literal replication, a multi-dimensional blend of cases has been selected, as shown in Table 4-5. The first dimension refers to the number of involved project partners. The underlying dimension of cultural diversity pictures the socio-cultural complexity of the inspected team environment. Finally, ‘industry’ as the third dimension adds the necessary bandwidth as it ensures a cross-industry examination of the phenomenon under investigation. Further discussion on the rationale of case selection can be found in section 4.5.2.

Table 4-5: Case-based research design for literal and theoretical replication

	Dimension 1: Number of involved project partners			
	<= 3		> 3	
	Dimension 2: Cultural Diversity			
Dimension 3: Industry	Low	High	Low	High
IT		**X**	**X**	
Environmental research				**X**
Telecommunication	**X**			
Airline				**X**
Engineering		**X**		
	1 case 5 interviews 9 surveys	2 case 7 interviews 28 surveys	1 cases 3 interviews 16 surveys	2 cases 7 interviews 18 surveys

Source: Developed for this research

Given the complexity and dynamics of virtual project environments it is expected that the pattern of data on team-based knowledge processes and associated aspects might vary across the first dimension, because more participating parties means more and different organisational process backgrounds and cultural belief systems as well potentially conflicting 'hidden' agendas or goals. Similar, the pattern of data might fluctuate across different categories of the second dimension, as cross-cultural work environments will enhance complexity and subsequently the likelihood of data variance. Nevertheless, focusing on these examples for theoretical replication, analysis might reveal somewhat similar results for case study settings with similar characteristics, thus representing literal replication. In summary, the utilisation of these two case selection methodologies will enhance internal as well as external validity. Next, the determination of number of cases and interviews and the corresponding sources will be discussed.

4.5.4 Number of cases, interviews, SNA questionnaires and sources of cases

Regarding the ***number of cases*** a total of six case studies comprising 22 interviews have been selected for this research. Qualitative researchers often struggle with the question what a case is and where its boundaries are (Miles & Huberman 1994). Miles and Huberman (1994) define a case as the unit of analysis while Stake (1995) claims that precise definitions of cases or case studies cannot be made, defining a case loosely as "a specific, complex, functioning thing". Within the context of this research, a case is defined as a formally documented virtual project team, being composed of several involved organisational groups or partners, striving to achieve the agreed upon project goal in a boundary-spanning environment.

Perry (1998) identifies two groups of researchers having distinctly different positions on the question as to how many cases a study should contain. Within the first group, refraining from suggesting a number and recommending the decision be left to the researcher (Romano 1989), Eisenhardt (1989) recommends that cases should be added until "theoretical saturation" is reached and Guba and Lincoln (1984) propose sampling selection "to the point of redundancy". And finally, Patton (1990) claims that there are no rules for sample size in qualitative research at all. The second group of researchers however is more specific on the number of cases to be used. For example, Hedges (1985) sets an upper limit of 12 cases because of the high costs involved in qualitative interviews and the quantity of qualitative data that can be effectively assimilated. Miles and Huberman (1994) argue that more than 15 cases make a study "unwieldy". Perry (1998) suggests an acceptable range of cases seems to fall between a minimum of two to four and a maximum of 12 to 15. Given the limited resources available to the researcher and the constraints faced in conducting the internationally oriented research investigation the design with six cases was considered both sufficient and practical.

The definition of the ***number of interviews*** for each case was guided by the need to acquire as much as representative data as possible within the individual virtual project team. Given the fact that each team consisted of several organisational groups or partners one interview with a key informant from each relevant party was conducted. In addition, when feasible, two interviews with members of the apparent dominant party was attempted. Thus, a number of at least three case study interviews per individual research setting seemed to be adequate to ensure the desired information-richness of the case study part of the main data collection. As highlighted in Table 4-6, a total of 22 main case study interviews were conducted. Adding the 12 convergent interviews, the two pilot study interviews and 17 individual depth-interviews, a total of 53 interviews have been carried out. This number of interviews fits with the minimum number of 20 to 50 respondents recommended by researchers such as Perry (1998).

The ***number of SNA questionnaires*** is directly depended upon the actual size of the investigated virtual project team. The desired collection of full network data, thus the whole virtual project team, allows for very powerful descriptions and analyses of social network structures, e.g. informal groups within a given team (Hanneman 2001). In essence, this approach is taking a census of ties in a population of actors - rather than a sample. Because information is collected about ties between all pairs or dyads, full network data provides a complete picture of relations within the individual case study setting and therefore represents an ideal supplement to the conducted case study interviews. Given the different team sizes, within a range of 9 to 27 members in each investigated case, a total of 71 SNA questionnaires have been conducted.

Possible ***sources of cases*** have been identified utilising different approaches starting in March 2003. Within a first phase, personal networks such as memberships in professional associations like PMI, IPMA or GPM have been used to establish appropriate contacts. In a second phase, speaker indexes of relevant knowledge management conferences have been analysed to identify further potentially interested contact persons within internationally operating companies or organisations. The third step included a mailing to enlisted members of the knowledge board (2003), an international internet-based knowledge community asking for support in the doctoral research activities.

As discussed in section 4.5.2 the final selection of cases should be based on the specific purpose of literal and theoretical replication. In this context, random sampling is inappropriate for this research because “random selection of cases is neither necessary nor preferable” (Eisenhardt 1989). Patton (1990) indicates 15 strategies of purposeful sampling which have been applied to support the final selection of case study settings. Thus, focusing on the group of potential candidates identified utilising the described procedure, intensity sampling as recommended by Patton (1990) has been used to select information-rich cases (see Table 4-6 for details) that can be studied in-depth.

Table 4-6: Classification criteria for case study settings

Criteria	Case study setting					
	A	B	C	D	E	F
Cultural focus	German	Diverse	Australian	European	Diverse	Diverse
Geographical focus	Germany	Global	Australia	Europe	Global	Asia
Type of industry	IT	Environmental research	Telecom	IT	Airline	Engineering
Size of project team(s)	27	12	14	30	21	23
Number participants	15	11	9	16	9	14
Number of involved project groups and/or partners	5	5	3	3	8	2
Number of project locations	3	6	4	10	7	3
Percentage of female team members	11%	45%	100%	6%	11%	0%
Type of dominant project partner	Communal administration	NGO	Private company	Private company	Company network	Private company

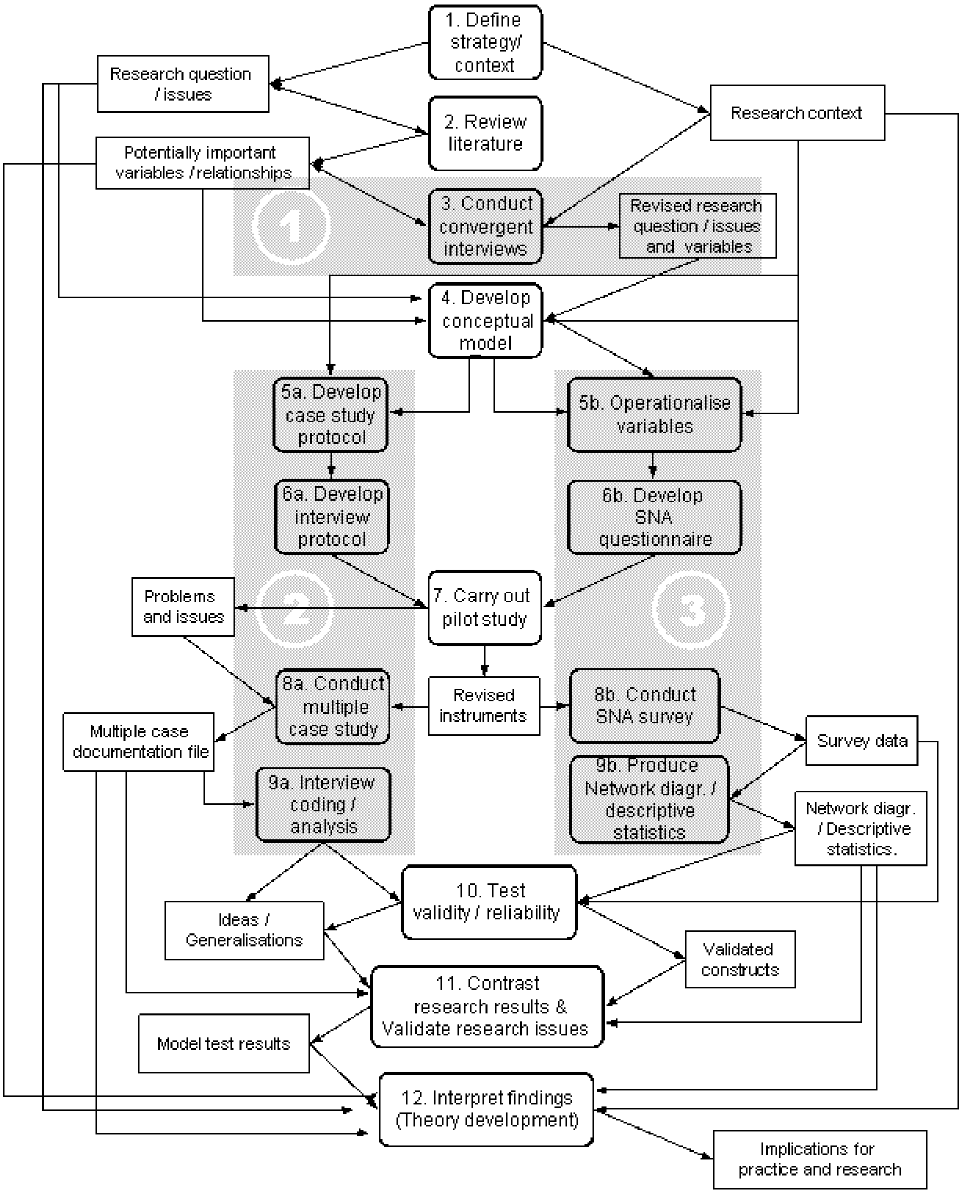
Source: Developed for this research

In summary, intensity sampling along the three dimensions mentioned earlier allowed information-richness of cases selected that manifest the phenomenon of interest intensively, thus achieving a good blend of theoretical and literal replication and ensuring rich insights drawn from later cross-cluster analysis (Chew 2001; Perry 1998).

4.5.5 Multi-method research design: The overall workflow

Figure 4-3 shows a flow diagram summarising the overall multi-method research methodology. The three applied methodologies, thus convergent interviews (1), case study (2) and Social Network Analysis (3) technique are highlighted appropriately. In the diagram, the rounded boxes represent processes or stages of the research study, whereas corresponding information flows are represented by 'square' boxes.

Figure 4-3: Multi-method research design: The overall workflow



Source: Developed for this research

4.6 Data collection procedures

The following four sections describe and discuss the main data collection process. First, the different data sources will be identified and then, in a second step, the general data collection strategy, utilising case study as well as survey techniques, will be explained. The next section covers a detailed discussion of the applied (main) data collection instruments, thus case study interview protocol and SNA questionnaire. Finally, based on the chosen data sources and the developed data collection methodology, the corresponding fieldwork procedures will be discussed.

4.6.1 Sources of data

The main data collection had a clear focus on *primary data*, thus 'data gathered and assembled specifically for the research project at hand' (Zikmund 2000, p. 124), whereas *secondary data*, like books, articles or the internet, has been used earlier in this research to provide a sound background to the study and to identify first preliminary research issues. Building on Miles and Huberman (1994) and Yin (2003) the necessary primary data for the qualitative part of the data collection has been gathered from several sources such as convergent interviews, depth interviews and case-related documents. Telephone-based depth interviews represented the major source of data used in this research because they provided valuable insights regarding the five research issues developed earlier (see section 4.6.3.1 for more details). Referring to Zikmund (2000) the quality of data obtained by telephone-interviewing may be comparable to that collected in personal interviews. The author adds that respondents may even be more willing to provide detailed and reliable information over the telephone than in personal interviews.

Based on the individual structure of the virtual project team and a comprehensive discussion with the project manager three key-informants have been selected as interview partners within each case study setting. The depth interviews encouraged interviewees to share their experiences and provide as much information as possible in a free-flowing environment (Cooper & Schindler 1998). Referring to the underlying research paradigm, the perceptions of the individual interviewees are of interest only because they provide triangulation data about the real world outside the interviewer and the interviewee (Perry 1998).

Multiple sources of evidence increases the sophisticated rigor of the data collection and analysis and also helps to reveal the richness and diversity of the investigated social setting (Neumann 2000). In addition, supplemental sources facilitate triangulation and enhance the validity of the data analysis (Patton 1990; Yin 2003). Hence, the other important data source which has been used – dealing with more quantitative aspects – was a survey-based Social Network Analysis (SNA). In contrast to the depth interviews which were conducted with selected individuals, this quantitative methodology targeted the entire virtual project team. Thus, between 7 and 16 team members within each case environment filled out the web-based SNA questionnaire (see section 4.6.3.2 for more details). The development of the multi-method data collection protocol discussed next.

4.6.2 General data collection protocol

Within the context of this research, focusing on knowledge management in virtual project teams, a structured protocol has been developed to control the contextual environment of the study (Emory & Cooper 1991; Yin 2003). This protocol deals with the case study part as well as with the survey part of the main data collection; it contains not only the data collection instruments such as the interview protocol or the SNA questionnaire , but also the procedures and general rules that should be followed in using the different instruments (Yin 2003). The protocol allows the researcher to systematically plan and document the information needs and procedures required for the data collection aspects of the study (Eisenhardt 1989).

Referring to the used multiple case design, Yin (2003) advises us that it is essential to use a protocol to improve the reliability of the research. And Perry (1998) adds that a systematic and rigid tactic provides direction that helps to improve the efficiency and focus of the research. As depicted in Table 4-7 the developed protocol incudes an overview, case study interview questions and survey questions, field procedures and guidelines for report writing. Each of these elements and its function within the research context is discussed below. The first element of the protocol, the *overview*, is addressed in chapters one and two of the dissertation. The research problem is explained in chapter 1, the literature relevant to the research problem is presented in chapter 2, whereas the research question and the five research issues are covered in chapter 3.

The second element, *interview questions*, forms the core of the interview protocol. The five research issues guided the development of several interview questions, listed in appendix D of this document, which have been used in all six case study settings for data collection purposes. The third element, the *SNA questionnaire*, represents a more quantitative supplement to the [qualitative] case study approach and is shown in appendix E of this paper.

Table 4-7: Elements of the general data collection protocol

Protocol element	Essential components	Dissertation chapter
Overview	• project objectives and auspices • relevant readings/literature • research question and issues	Chapter 1 Chapter 2 Chapter 3
Case study interview questions (Interview protocol)	• specific interview questions • potential sources of answers	Appendix D Chapter 4
SNA Questionnaire	• specific survey questions • potential sources of answers	Appendix E Chapter 4
Field procedures	• credentials • access to case-related key-informants and team members • general sources of information • procedural reminders	Chapter 4 Chapter 4 Chapter 4 Chapter 4
Guidelines for report of findings	• outline • format • other documentation	Chapter 5 Chapter 5 Chapter 5

Source: Developed from Yin (2003, p. 64-65)

The *field procedures*, as next element, are discussed throughout this whole chapter. To ensure a good preparation of all ‘on-site’ activities and a stress less interview atmosphere the details of the fieldwork have been worked out and documented in advance (see section 4.6.4). Considerable lead-time was needed to schedule the case study interviews as well as to track (and sometimes to push) the completion of the SNA questionnaire within the different case study settings. The use of telephone and e-mail for communication was fully exploited. Because confidentiality was critical as the organisations and individuals considered ‘knowledge about [their] knowledge’ as a highly valuable asset they voiced a very clear preference to remain anonymous as a precondition to participate in the study. Thus the names of the six participating companies were alphanumerically coded as case A to F to conceal their identity. The last element, *guidelines for report of findings*, describes the outline and format of the communication of the research findings and is discussed in chapter five of the dissertation in detail.

4.6.3 Data collection instruments

The developed multi-method approach utilised two supplemental data collection instruments to establish the necessary reservoir of qualitative and quantitative data for later analysis. These two devices, namely a case study interview protocol and a SNA questionnaire, will be discussed next.

4.6.3.1 Case study interview protocol

The interview protocol is an element of the general data collection protocol and serves two major functions in this research (Yin 2003). First, it forces the researcher to think through the questions to be asked during the interviews. Second, the interview protocol enables the questions to be grouped according to the research issues and thus facilitates subsequent data analysis. Table 4-8 provides a summary of the research issues and the related interviews questions contained in the case study interview protocol. The interview protocol is divided into 9 segments (Part A to I) and is given in full length in appendix D of this paper.

Table 4-8: Summary of the research issues and related interview questions

Research issues	**Interview questions**
RI 1: How do the level and type of trust within a virtual project team affect the creation and exchange of knowledge?	Questions C1 to C9 (Part C)
RI 2: How can a shared language and a common vocabulary impact knowledge management in virtual project teams?	Questions D1 to D7 (Part D)
RI 3: To what extent do informal networks influence the knowledge creation and exchange in virtual project teams?	Questions F1 to F5 (Part F)
RI 4: How do boundaries support or hinder knowledge creation and exchange?	Questions E1 to E7 (Part E) (as well as single aspects of part C, D, F and G)
RI 5: What are the risks associated with limited awareness regarding the quality of the existing knowledge repository and uncontrolled knowledge diffusion processes in virtual environments?	Questions G1 to G7 (Part G)
Additional information to help solve the research question	Questions B1 to B6 (Part B) Questions H1 to H8 (Part H) Questions I1 to I4 (Part I)

Source: Developed for this research

The first part introduces the research project and outlines ethical considerations as well as additional notes. Part B provided the opening questions which invites the interviewee to tell the story of their experiences on the research subject, thus knowledge management in virtual project teams, to build the necessary rapport (Perry 1998). In addition, this part contained more specified questions e.g. regarding the team member's receptivity on knowledge management and accompanying organisational background questions to prepare the ground for the next important parts of the interview protocol. The questions in parts C to H relate to the five research issues respectively. Each of these parts consists of adequate probe questions and related Likert-style questions to summarise the interviewee's perceptions. The final part I include additional questions which gives the interviewees the opportunity to express their opinions on any other issue they feel are important but not asked and to give their assessment of the quality of the questions asked. The interview protocol was tested in the pilot study (see section 4.7) before the main data collection started.

4.6.3.2 SNA questionnaire

The utilisation of an online tool, which collects information directly from the subjects, was the most suitable approach for this research. Collecting data from the team members of internationally distributed project teams, using any other method was not practical, due to cost of using postal questionnaire, telephone interviews or onsite visits as well as focusing on the number of questionnaires. A password protected version of the IKNOW Gateway (see appendix F) provided by the University of Illinois at Urbana-Champaign has been used for data collection (and partly analysis) purposes. The application was customised for this research, so that it was able to collect supplemental data and information to support the - holistic as possible, but focused as necessary - verification of the five research issues and finally the research question.

The information has been collected from the subjects; hence team members of the investigated virtual project teams, by a self-administered profile, based on a number of attributes (see appendix E). The attributes used for the SNA questionnaire and initial profiles for members of the individual case, have been created based on a study by Borgatti and Cross (2003) as well as referring to preliminary discussions with case-related key-informants. In essence, the questionnaire is structured around the idea that information / knowledge exchange is a function of the extent to which a person *knows* and *values* the expertise of another, the *accessibility* of this person and the potential *cost* incurred in seeking information or knowledge from this person. The involvement of the team members in the SNA survey was promoted through (Swarbrick 2002):

- using the project manager and relevant representatives of the involved groups/organisations as high level sponsors for the research;

- using a sophisticated web-based application to act as a single point of contact for the cost-effective and timesaving data acquisition, and
- the production of guidance documents and appropriate support to make using the application more straight forward.

4.6.4 Fieldwork for data collection

The research adopted a systematic, eight step process of conducting the fieldwork for the multi-method data collection, which is discussed next. *First*, firms have been approached and appropriate organisational representatives identified. *Next*, these contact persons (and possibly participating project teams) have been provided with prepared presentations to explain the research and the data collection process, assuring them about confidentiality and anonymity. The *third step* focused on the identification and selection of adequate virtual project teams based on the criteria discussed in section 4.5.4. *Then*, after preliminary talks with the responsible project manager of the selected virtual project team, additional key-informants belonging to relevant (internal) project groups or (external) companies/partners were chosen and overall commitment was insured.

Fifth, a minimum of three team members, usually the project manager and two key-informants referring to the involved stakeholder groups, were interviewed. The researcher adopted a semi-structured interview approach as this allows the respondents greater freedom to express their views. Each interview started with a general introduction to acquaint the interviewee with the interview purpose and agenda as contained in the interview protocol in appendix D. In parallel, the quantitative data collection via SNA questionnaire has been initiated where all known members of the investigated virtual project teams have been targeted. In the *following step* the interviews were documented using reports and send to the interviewees to check for errors and adding information as necessary.

The *seventh* step was to triangulate the collected data sources, thus qualitative case study interviews and quantitative survey data, and to integrate the findings on a case-related basis. *Finally*, the case report was send to the three interviewees of the participating virtual project team to review the case content and clarify any discrepancies or inaccuracies (Chew 2001).

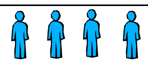
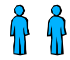
4.7 Pilot study

In combination with the literature review and exploratory interviews, pilot case studies assist the researcher in developing prior theory and general approaches for the main data collection process. Moreover, pilot case studies are considered to be an effective tool to assess the usefulness, reliability and validity of the interview protocol and/or corresponding questionnaires (Eisenhardt 1989; Yin 2003). As depicted in Figure 4-3, pilot case studies help the researchers to review and revise their data collection protocol before the main data collection commences.

Focusing on the interview part of the data collection, content issues have been clarified and the researcher sought input from the interviewees on the interview duration and comprehensibility to integrate the findings in the final procedure applied in the main cases. Referring to the SNA survey, the focus was on aspects like understandability and usability, because, in contrast to the case interviews, no direct feedback or support can be provided. Care was taken that the pilot case was not an extreme case (Stake 1995; Yin 2003), i.e. preparatory discussions with team-based key-informants insured that the appropriate virtual project team had a stable background. Furthermore it is desirable, more so in the pilot case than in the main cases, that the interviewees and survey participants are supportive of the study (Yin 2003). The pilot case is an integral part of the case study method, leading to a refined and relevant main case format. It is not to be considered a practice run of the main cases (Yin 2003; Perry 1998; Zikmund 2000).

Because of geographical and budgetary constraints, two pilot interviews were conducted and seven SNA questionnaires collected for this research rather than the usual ‘full’ pilot case study. The interviews and the web-based SNA survey have been conducted within a project involving two German medium-sized companies in the IT respectively multimedia sector (see Table 4-9). In total seven, knowledgeable and interested representatives of the project team were approached for the two pilot interviews as well as for the survey to help the researcher fine-tune relevant lines of questioning and also to provide some feedback on the overall research design (Yin 2003).

Table 4-9: Pilot Case - Overall team structure and geographic distribution

	Geographic location		
Organisation	City 1 (a)	City 1 (b)	City 2
IT Service & Consulting Company			
Client			

Source: Field data

The interview protocol (see appendix D) as well as the SNA questionnaire (see appendix E) developed for this research were refined after the completion of the pilot case study. Modifications have been made to two questions in the interview protocol to enhance understandability and the query sequence in the SNA survey has been adapted. In addition, the pilot study showed that the estimated interview duration should be extended for about 25 percent to avoid time pressure. On the other side, it came apparent that the SNA survey could be completed in around 30 percent less time. Relevant data and findings regarding the pilot study are presented in chapter 5 as well as in appendix M. After completing the pilot study and the subsequent refinement of the data collection instruments, the main data collection process started using the fieldwork procedures (discussed in section 4.6.4). After completion of the data collection from six cases, the acquired data were analysed as documented in chapter 5 of the dissertation.

In summary, two pilot interviews and seven SNA questionnaires were used to substitute a full pilot case study. The appropriate feedback helped refine the interview and survey procedures as well as to add relevance to the questions and provided some practice for the researcher. Having discussed the pilot case procedures, the main case data analysis methods are discussed next.

4.8 Data processing and analysis

To address the research problem and the associated questions the data collected from the case studies needs to be compiled, examined and analysed (Eisenhardt 1989; Miles & Huberman 1994). Yin (2003) stresses that a general analytic strategy should be in place, before tool selection and data manipulation activities begin. A well organised data analysis and documented procedures add credibility and value to any [qualitative] study (Miles & Huberman 1994; Yin 2003). While the strategy and related data analysis processes are presented in chapter 5 of the dissertation in full detail, some of the data analysis methods suggested in the literature are discussed briefly in this following two sections.

4.8.1 Case study interviews (Qualitative Data)

Based on Zikmund (2000) and Miles and Huberman (1994), data processing and analysis of the acquired structured and unstructured qualitative data followed several general steps, which will now be described in chronological order:

Editing. Editing is the process of checking and data for omissions, legibility and consistency (Zikmund 2000). The purpose of editing is to ensure completeness, consistency and reliability of the data to be transferred to data storage (Sonquist & Dunkelberg 1977). While the unstructured part of the interview protocol remained in text format, the structured part, esp. the Likert-scale questions, has been translated into numeric matrix-style format to allow for better data handling and subsequent analysis.

Coding. Coding is two simultaneous activities: mechanical data reduction and analytical categorisation of data into themes. In general coding systems identify one or more of four characteristics of text content: frequency, direction, intensity and space (Neumann 1994). Strauss (1987) defined three kinds of qualitative coding, which have been used for this research:

> *Open coding* is performed during a first pass through the collected unstructured data. Throughout the open coding process appropriate themes have been located and in a first attempt initial codes or labels assigned to condense the mass of data.
>
> The *axial coding* represents the “second pass” through the data where the researcher focuses more on the initial coded themes than on the data. Additional themes and new ideas may emerge during this pass and the researcher moves towards organising ideas or themes a well as identifying the axis of key concepts in the analysis. During axial coding the focus lies on causes and consequences, conditions and interactions, strategies and processes, and looks for categories or concepts that cluster together (Neumann 2000, p. 423).

> *Selective coding* begins after well-developed concepts are in place and the overall analysis has been grouped around several core generalisations or ideas. The researcher looks selectively for cases that illustrates themes and makes appropriate comparisons and contrasts.

Within-case Analysis. After coding the collected data, content analysis was used to identify core themes within each interview and each case, since content analysis is a technique for showing consistency and regularity (Miles & Huberman 1994). Content analysis frees a researcher from entanglement in the details of the raw data and encourages higher level thinking, thus new concepts can be formed or old ones refined. In addition it moves him or her towards theory and generalisations (Neumann 2000, p. 420). To support the examination process the data was displayed in graphs, tables and/or matrices. These visual displays helped e.g. in tabulating the frequency of different issues and in examining the complexity and relationships between these issues.

Cross-Case Analysis. The cross-case analysis provided valuable insights into the different knowledge structures and processes if the investigated virtual project teams. Referring to the wealth of data and information focusing on the underlying research issues the cross-case analysis (as well as the following cross-cluster analysis) offered the possibility for the researcher to display analytical capabilities and deductive thinking (Perry 1998; Yin 2003). Reported differences between cases were supported by direct quotes from interviews and other sources (Perry 1998). This further improved the credibility of data analysis in this research (Chew 2001). Finally, evidence from the individual expert interviews will be used to enrich the cross-case analysis.

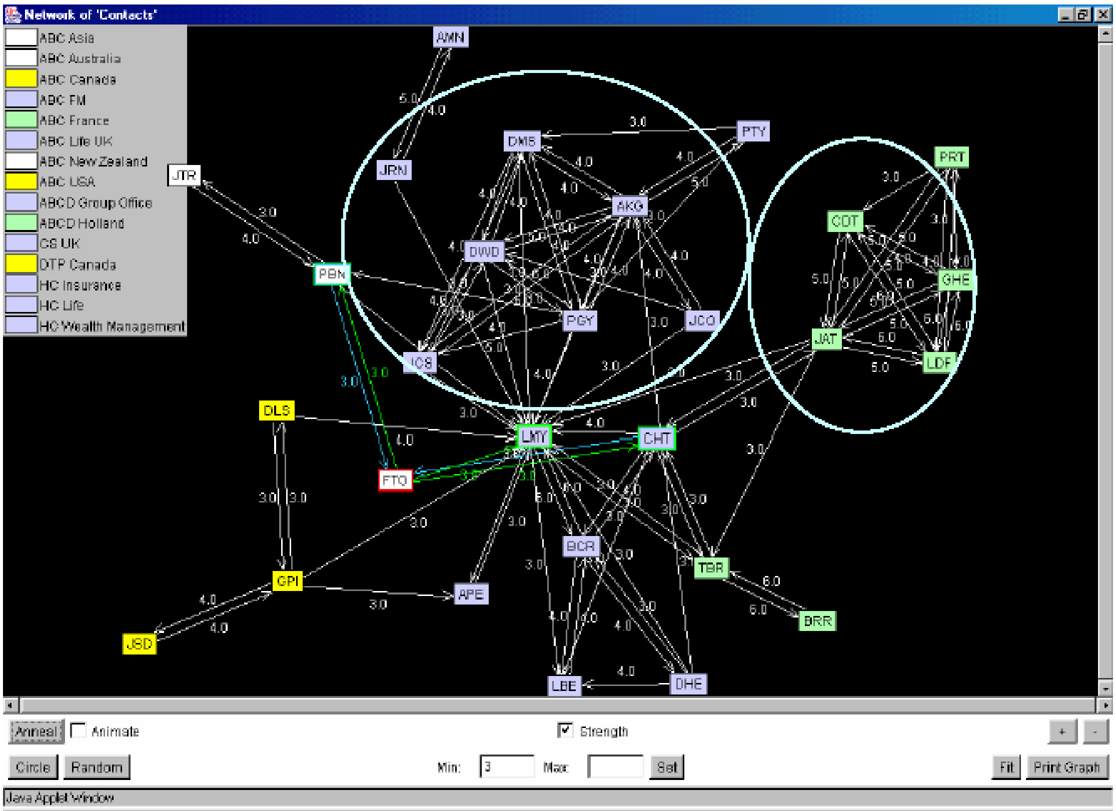
Cross-Cluster Analysis. The cross-cluster analysis allowed the researcher to draw out general themes rather than individual case uniqueness. Using the technique of cross-cluster analysis, further conclusions can be made and verified and the overall reliability of the research can be increased (Eisenhardt 1989).

Conclusion and Verification. The final phase of the qualitative data analysis was conclusion drawing and verification to develop meanings from the data displayed (Miles & Huberman 1994). This last step in the analysis process focused in building conceptual/theoretical coherence through comparisons with prior theory in the existent literature, seeking out opportunities to replicate the research findings (Miles & Huberman 1994). This is further elaborated on in chapter 7 of the dissertation.

4.8.2 SNA questionnaires (Quantitative Data)

Social network analysts use two kinds of tools to represent information about patterns of ties among social actors: graphs and matrices (Hanneman 2001). A **graph** (sometimes called a sociogram – see Figure 4-4) is composed of nodes (or actors or points) connected by edges (or relations or ties). Graphs are very useful ways of presenting information about social networks. However, when there are many actors and/or many kinds of relations, they can become so visually complicated that it is very difficult to see patterns.

Figure 4-4: SNA Analysis: Development of sociograms using IKNOW



Source: Swarbrick (2002)

It is also possible to represent information about social networks in the form of **matrices**. Representing the information in this way also allows the application of mathematical and computer tools to summarise and find patterns. Once a pattern of social relations or ties among a set of actors has been represented in a formal way (graphs or matrices), we can define some important ideas about social structure, e.g. informal knowledge networks and associated processes, in quite precise ways using mathematics for the definitions (Hanneman 2001).

In the context of the investigated knowledge networks, the entities are actors (team members, groups, organisations, etc.) and the relations between the entities represent the knowledge they share in common. The metrics developed in network analysis (see footnote[3]) can easily be extended to the study of knowledge networks (Cross et al. 2002). Network analysis can also be used to measure cognitive knowledge networks. For instance, an actor whose cognitive knowledge network accurately maps on to the observable knowledge network is more likely to be identified as the one "who knows who knows what." In general, network analysis offers the ability to measure the evolving characteristics of knowledge networks with a degree of precision that might otherwise be defined only in metaphorical terms (Contractor et al. 2002).

Because a picture really is worth a thousand words, visual analysis of the collected SNA data using graphs played an important role. The tools IKNOW (see Appendix F) and UCINET (see Appendix G) allowed the researcher to visualise the network data in a various number of ways (Detailed information is provided in chapter 6 of the dissertation). To ensure a systematic and reliable analysis process a fixed analysis sequence regarding the case-by-case investigation was maintained: In a first step, visible relationships in network graphs have been identified, then central vs. peripheral actors compared and finally subgroups investigated. In a second step, these first qualitative findings have been compared and contrasted with calculated quantitative indices. This second part of the network analysis has been carried out using UCINET a comprehensive and advanced software package for social network analysis. The selection of the indices (see Table 4-10) has been guided by findings presented by Cross and Parker (2004), Wassermann and Faust (1999) as well as based on feedback from two discussion forums (UCINET 2004; SOCNET 2004). In summary, the used processing and analysis tools offered a wide range of sophisticated functionalities and build-in calculations and thus freed the researcher from many common and laborious analysis activities.

---

3 Network properties of individual actors (e.g., actor connectedness, range, prominence, betweenness, isolation, popularity, and centrality), dyads (e.g., reciprocity, symmetry), triads (e.g., transitivity) and global characteristics of the overall network (e.g., network density, heterogeneity, and centralization).

Table 4-10: Social Network Analysis: Calculation of relevant indices

Metrics / Indices	
Individual measures	
	• Simple Prestige
	• Proximity Prestige
	• Degree Centrality
	• Closeness Centrality
	• Betweenness Centrality
	• Brokerage
Network measures	
	• E-I Index
	• Density
	• Cohesion

Source: Developed for this research

4.8.3 Triangulation

Triangulation is particularly appropriate for initial, theory-building research in an area like knowledge management in virtual project environments, because it provides "thick descriptions" of phenomena and facilitates their interpretation. Denzin and Lincoln (1994) argue for a triangulation of multiple methods and theories saying that they improve the likelihood that interpretation will be acceptable, through the support they provide to each facet of data collection.

Silverman (1993), on the other hand, warns against the triangulation of different accounts, believing that if triangulation is used it should be done so sparingly, and not necessarily at all stages of data collection. He explains that using data to adjudicate between accounts, forces the researcher to undercut one account with another. In effect, this ignores the context-bound and skilful character of social interaction. If accounts are context-bound, they cannot be verified by generating data in multiple ways and from multiple sources. Such data cannot be added together to produce a more complete picture, it is an end in itself.

In the context of this research, triangulation has been applied primarily during the within-case, cross-case and cross-cluster analysis to initiate synergetic effects referring to the conducted qualitative and quantitative data collection. Jick (1983, p. 144) suggests that the process of compiling research material based on multi-methods is useful whether there is convergence or not. Where there is convergence, confidence in results grows considerably; findings are no longer attributable to a method artefact (Gable 1994). Also, ‘in seeking explanation for divergent results, the researcher may uncover unexpected results or unseen contextual factors’ (Jick 1983, p. 144). Thus, 'triangulation may be used not only to examine the same phenomenon from multiple perspectives, but also to enrich our understanding by allowing new or deeper dimensions to emerge (Jick 1983, p. 138).

In summary, the research employed multiple methods, e.g. convergent and depth interviews, survey data, and archival data, to study knowledge generation and sharing in dynamic and complex virtual project environments. The triangulation of research methods yields a rich payoff in terms of empirical insight, a balance of internal and external validity, and robust findings.

4.9 Limitations

Four problems with a pure qualitative case study approach are often cited when discussing the appropriateness of the critical realism research paradigm (Perry, Riege & Brown 1999). These are first, a lack of controllability, second, a lack of deductibility, third, a lack of repeatability and fourth, a lack of generalisability (Lee 1989). To overcome these issues and to enhance the overall quality of the research a multi-method approach has been developed combining qualitative and quantitative techniques, to compensate major weaknesses of case study research with the strengths of a survey-based SNA approach and vice versa (see chapter 4.3 for details). Nevertheless, some general remarks have to be issued.

Generalisability. Due to the chosen research paradigm and the research design, this study strives for analytical generalisation. To achieve sufficient statistical generalisation a subsequent comprehensive survey research has to be conducted.

Deductibility. The complexity of the issues and the absence of clearly defined independent and dependent variables and measures do not allow theory building from deduction. This research uses an inductive approach to establish theory (Perry 1998) and does not seek or claim deductibility. In this context the applied quantitative technique supplements the qualitative methodology during theory development, but is not used to test a developed theory.

Controllability. Virtual project environments are characterised by their socially complex and dynamic nature. To ensure a sufficient controllability of the research environment, care was taken in the selection of the project teams under study that they had a positive and supportive attitude towards the area of research. In addition, clear and systematic research procedures like protocols and guidelines as well as an honest information policy help to gain the necessary control.

Repeatability. Knowledge management itself and projects as well are both ongoing processes. It is not possible to turn the clock back and 'repeat' individual aspects under the same circumstances as would be in a controlled experiment. It is again this lack of repeatability that justifies and necessitates a field study over an experiment in this inductive theory-building research.

Table 4-11: Limitations of the multi-method research approach and related strategic responses

Criticism of research approach	Strategic responses to overcome shortcomings	Sections where limitation is addressed
Case study methodology		
1. Results in overly complex theories	Develop prior theories and specific research questions	Chapter 2
2. External validity	Use theoretical replication logic, compare evidence with existent literature	Section 4.5.3
3. Difficult to conduct	Use case study protocol and a systematic fieldwork process	Section 4.6.2 and 4.6.4
4. Not sufficient for sound theory development	Use multiple methodological approaches	Section 4.5.1
5. Researcher bias and lack of rigor	Use of validity checks and discussion with other researchers and practitioners	Chapter 4.4
Telephone interviews		
6. Absence of Face-to-Face contact	Use multiple data collection approaches to broaden the quantitative and qualitative range of data sources	Section 4.6.1
7. Limited duration	Insure interviewees' interest regarding the area of research. Systematic and not to complex interview protocol	Section 4.6.1
SNA survey methodology		
1. Problems with self administered online questionnaire	Use a structured and well designed survey. Include explanatory material and offer additional support	Section 4.6.3.2 as well as appendices E and I
2. Participant workload	Use short, but methodologically sufficient questionnaire. Insure respondents interest and offer rewards, e.g. a summary of results	Section 4.6.3.2 as well as appendices I and J

Source: Developed from Eisenhardt (1989), Parkhe (1993) and Yin (2003)

Table 4-11 addresses the identified limitations of the multi-method research approach in more detail and presents appropriate strategic responses. The two following sections will discuss both aspects in relation to the used methodology.

4.9.1 Limitations of the applied case study methodology

The first limitation, issued by Stake (1995), focuses on the inappropriateness of case study research regarding the development of complex theories. In the context of this study, the development of specific research issues in chapter 3 of this dissertation assured a clear focus during the research. The development of tentative theories and the use of convergent and expert interviews helped the researcher to focus on only important core issues of the research.

The second criticism suggests that case study methodology is unable to achieve external validity even with careful replication. To counteract this potential shortcoming, this research used a multi-method approach in combination with a sophisticated replication logic strategy across all case studies. External validity was further enhanced by conducting a retrospective comparison of the collected data with the literature in chapter 7 of the dissertation.

The third criticism is that case study research is difficult to conduct due to operational and logistical problems (Yin 2003). In this research, this problem was addressed by the use of efficient and cost-effective research techniques like telephone interviews and web-based surveys for the main data collection. Hence, an international focus could be maintained without exceeding the researcher's financial and time-related resources. In addition, a carefully planed data collection protocol including well prepared fieldwork procedures helped to keep potential problem sources under control.

The fourth criticism of case study research is that it is not sufficient for sound theory development (Stake 1995). This research addresses this limitation by using multiple approaches such as the convergent, depth exploratory and pilot case interviews for prior theory development during the exploratory stage and a combination of case study and survey techniques during the confirmatory/disconfirmatory stage. Moreover, further quantitative research is suggested when discussing implications for future research.

The fifth criticism concerns the impact on the research by the researcher's bias upon the respondent's answers to the case study interview protocol and interpretation of the data (Stake 1995; Zikmund 2000). To avoid bias, the research design, data analysis and findings were discussed with other knowledgeable researchers, experts and practitioners. Validity checks to ensure consistency of interpretation were used rather than depending on the researcher's interpretation only.

The last two limitations refer to the applied telephone interview technique. Zikmund (2000) argues that the missing face-to-face contact and a limited duration of the interview might influence the research in a negative way. To address the first criticism, thus the lack of visual feedback, a mix of multiple data collection approaches has been used to broaden the quantitative and qualitative range of data sources. Zikmund (2000) puts in that in non-face-to-face interviews, respondents might be even willing to provide more sensitive information. Regarding the second issue, Struebbe et al. (1986) suggested an average duration of 10 minutes and a maximum of 30 minutes for telephone interviews. Referring to the researchers own experience based on twelve convergent telephone interviews with interested interviewees, the optimal duration is about 45-50 minutes. In this context a systematic interview protocol and not too complex questions should be used to support the telephone-based data collection process.

After discussing limitations focusing on the applied qualitative case study methodology including telephone interviews, the next section will now focus on the utilised quantitative technique, thus SNA (Social Network Analysis) survey.

4.9.2 Limitations of the implemented SNA survey methodology

It is common tho assume that observations or measurements of a concept are an additive combination of the ‘true’ score plus error (Wasssermann & Faust 1999). Thus it is likely that the developed visualisations of informal networks may differ to a certain degree from the ‘true’ structure. The online application used to collect the necessary SNA data was self administered by the case study participants. To avoid (or better control) operational and technical problems a well designed SNA questionnaire has been developed and tested. In addition, each respondent received appropriate explanatory material and has been offered additional support. Although each data set was checked, it is possible that some of the profiles could have been completed by proxy (Swarbrick 2002).

Because this study was conducted outside of the remit of the organisation, it was unable to command the same status as other network initiatives that the particular organisations were involved in. This meant that busy team members were limited in the amount of time that they could allow to the study. To handle this potential problem a short, but methodologically sufficient questionnaire has been developed and used. Moreover, in cooperation with the respective project manager and other key-informants of the involved organisations/partners, the individual respondent's interest has been increased in advance using an adequate information (marketing) policy and, in addition, appropriate rewards, e.g. a summary of results, have been offered.

In summary, with the addressed precautionary steps taken, the developed multi-method research design represents a sound approach for this study targeting knowledge management in virtual project environments. Having addressed the limitations of this study, ethical considerations in this research are discussed next.

4.10 Ethical considerations

Ethical considerations are an integral part of academic research methodology (Miles & Huberman 1994; Zikmund 2000) and an agreed upon code of ethics and appropriate research practices / procedures provide guidance, but finally the individual researcher is responsible to conduct his research in an ethical manner and to insure the truthfulness of the analysis and reporting in his research inquiry (McPhail 2002). Emory and Cooper (1991) warn that the quality of the research may be harmed if the issue of ethics is not addressed adequately. Although there is no general agreement about answers to ethical questions that surround business research, there exist societal norms suggesting codes of conduct that are appropriate in given circumstances (Zikmund 2000).

Four principles of ethical standards are often cited, namely voluntary participation, informed consent, avoidance of harm, and confidentiality, which will now be addressed in more detail (Miles & Huberman 1994; Trochim 2003):

Voluntary participation requires that people not be coerced into participating in research (Trochim 2003). The investigated virtual project teams consisted of several, organisational or hierarchical more or less independent, organisational groups or partners (e.g. other companies or organisations) and due to the temporal restricted character of the teams, there existed no direct team-related disciplinary relationships. After the research project has been presented and explained, each project team decided autonomously, whether to participate or not. Only a clear agreement of the whole team (involving all project groups or partners) regarding the case study interviews a well as focusing on the Social Network Analysis (SNA) survey initiated further steps. After consultations with key-informants from all stakeholder groups, the proposed interview partners were approached directly and voluntary participation was verified. After initial consent the researcher secured consent from the superior of each interview partner.

Informed consent means that prospective research participants must be fully informed about the procedures and risks involved in research and agree to participate (Trochim 2003). All participants received an informed consent form explaining the research and related issues in detail upfront and were requested to send back the signed document before commencing any further (see Appendix J for details). In addition, the purpose and details of the depth interviews are also explained in the interview protocol which was made available to each interview partner and, if requested, to relevant representatives. Referring to the SNA survey, each team member received an introductory email in advance, clearly explaining the overall background, the proposed use of the collected data and privacy and confidentiality issues (see Appendix H for details).

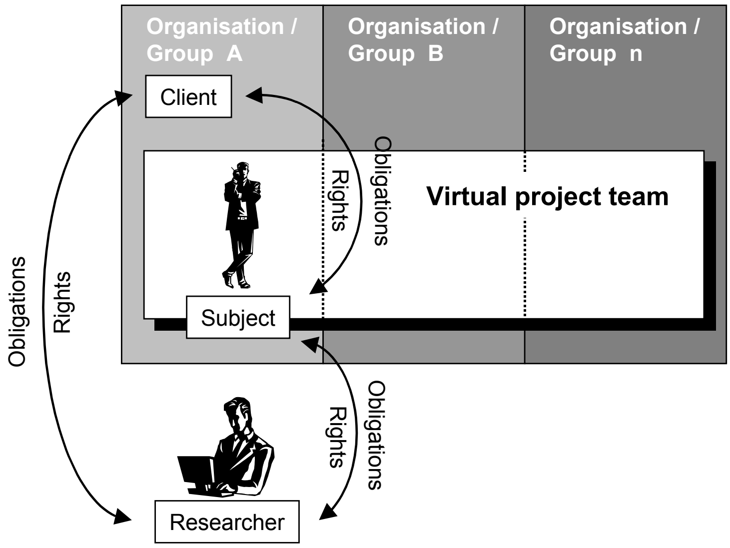
Avoidance of harm. Ethical standards require that researchers not put participants in a situation where they might be at risk of physical or psychological harm as a result of their participation (Stake 1995; Trochim 2003). In this research physical harm was not considered a potential risk and psychological harm was eliminated by the team-based participative decision process described earlier and the fact that no direct disciplinary relationships existed within the investigated project teams. In addition, after an interviewee's voluntary consent the researcher tried to obtain approval also from those who could cause psychological harm, i.e. the superiors.

Confidentiality is required to protect the privacy of research participants (Trochim 2003). Care and due diligence were exercised throughout all personal exchanges to respect and maintain the privacy and confidentiality of the interview partners and survey respondents (Miles & Huberman 1994). Anonymity was agreed upon for all participating companies and organisations as well as all involved team members. The respondents were assured that the research results would not be used for purposes other than academic knowledge and advancement (Neumann 2000).

Finally, ethical considerations were incorporated into the research design from the beginning, based on the ethical guidelines of the Research and Higher Degrees Committee of the Faculty of Business and Commerce of the University of Southern

Queensland. For example, each participant/respondent has been assured that they may withdraw from the study at any time without any fear of the consequences. This in turn led to free and frank disclosure by relevant representatives of the investigated virtual project teams during preparation as well as focusing on the final interview partners or survey participants.

Figure 4-5: Ethical rights and obligations within the research environment



Source: Developed from Zikmund (2000)

In summary, keeping a good ethical stand is not the researcher's task alone, but he should be the advocate of appropriate ethical research practices and procedures. In the investigated business research situation(s) there are [generally spoken] always three involved parties: the researcher, the sponsoring parent organisation and the individual team member. Each party has certain rights and obligations (see Figure 4-5). The *team member's* (subject) rights include privacy and being informed about all aspects of the research; the respondent's main obligation is to provide honest answers to interview or survey questions. The *organisation* (client) is obligated to observe general business ethics when dealing with research suppliers; avoid misusing the research findings to support its aims; respect research respondent's privacy; and be open about its intentions to conduct research and the business problem to be investigated. And finally the *researcher*, who is expected to adhere to the purpose of the research; maintain objectivity; avoid misinterpreting research findings; protect the individual's and the organisation's right to confidentiality.

4.11 Summary

This chapter reviewed and justified the use of the critical realism paradigm and the developed multi-method research approach, utilising case study methodology and survey-based social network analysis, for the investigation of knowledge management in virtual project environments. It was argued that through the combination of the discussed methods the robustness of results can be increased and findings can be strengthened though cross-validation. Comprehensive and effective principles have been taken into account to ensure a sufficient quality of the research design without forgetting the inherent geographical and financial constraints of the study. Thus, the triangulation of the combined research methods has the potential to yield a rich payoff in terms of empirical insight and simultaneously keeping a balance of internal and external validity.

Further, relevant aspects of the developed multi-method research design, like the process of theory building, selection criteria and replication logic as well as number and sources of cases have been discussed. The two utilised data collection instruments, the systematic fieldwork procedures and the layout of the pilot study were presented. In a final step limitations and corresponding precautionary steps taken as well as ethical considerations as integral part of academic research methodology have been addressed. Next, the data collected from the cases using the introduced qualitative (chapter 5) and quantitative methodologies (chapter 6) are analysed and corresponding results presented and discussed.

5 RESULTS: ANALYSIS OF INTERVIEW DATA (QUALITATIVE)

5.1 Introduction

"Who knows useful things, not many things, is wise"
[Aeschylus]

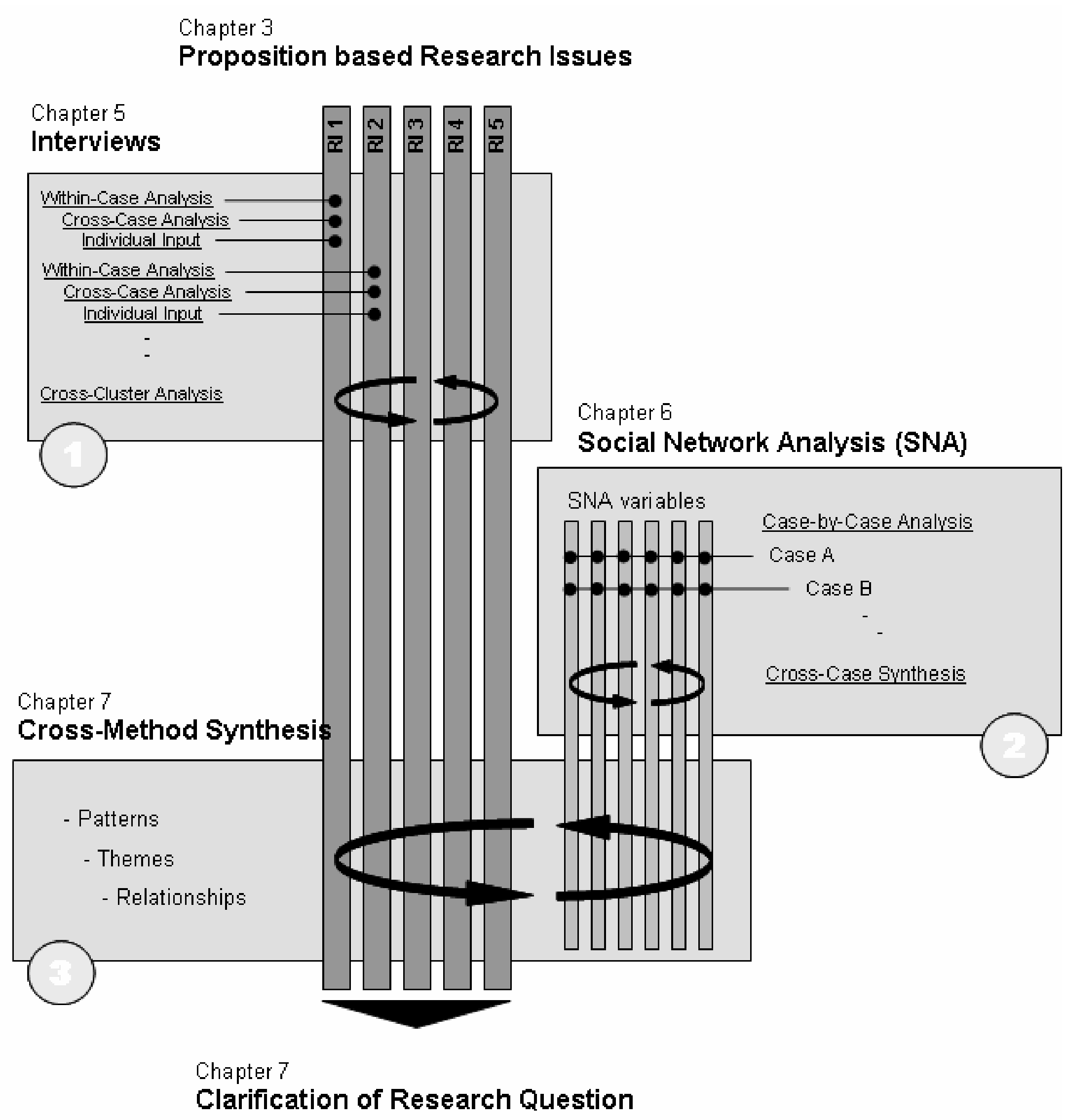
The preceding chapter elaborated the two-track research methodology consisting of qualitative and quantitative approaches, cooperatively having the potential to provide significant insights regarding the complex and highly dynamic knowledge processes in virtual project environments. The objective of this chapter is to present, examine and interpret qualitative data and patterns for their relevance to the research issues. This part begins with an overview of the analysis strategy and data display. Then, the background of the six case study projects at large is discussed, team structure described and related descriptive information is provided.

To enhance readability and transparency qualitative (Interviews) and quantitative data sources (Social Network Analysis) are handled separately using two distinct chapters, thus chapter 5 and chapter 6, because each part can be viewed as independent examination of the same phenomenon. Both chapters include frequent summary tables and figures supporting the overall integrative analysis process. Due to the fact that both methodologies investigate different dimensions of individual social eco-systems, the final chapter 7 presents and discusses a cross-method synthesis of obvious patterns and tentative relationships, trying to find links between socio-cultural aspects like trust, language or barriers and network-related variables like information / knowledge exchange, accessibility and contact frequency. Next, the overall analysis strategy, utilised analysis techniques and data display will be described.

5.2 Analysis strategy and data display

Yin (2003) highlights that the best preparation for conducting case study analysis is to have a general analytic strategy. An appropriate strategy will help the researcher to treat the evidence fairly, produce compelling analytic conclusions, and rule out alternative interpretations. In detail, Yin (2003) recommends one of three strategies for data analysis. First, relying on theoretical propositions, second, setting up a framework based on rival explanations or, third, developing case descriptions. This study employed the first strategy, thus *theoretical propositions*, hence the overall analysis follows the research issues, which in turn developed from propositions on knowledge management in virtual project environments derived from the literature review in chapter 2 and refined in chapter 3 'Analytical framework'.

Figure 5-1: Overview analysis process and cross-method synthesis



Source: Developed for this research

Within the context of the chosen analysis strategy several complemental analysis techniques have been used to investigate the collected data (see Figure 5-1). In a first step q*ualitative interview data (1)* has been analysed using a gradual process dealing with within-case, cross-case and supplemental expert evidence, whereby each research issue has been handled individually. The subsequent cross-cluster analysis tried to highlight patterns and themes across all five research issues emerging from the case data. To support the data coding activities as described in section 4.8.1 and to allow for a better data handling all 53 interviews have been transcribed in tabular format. As depicted in Figure 5-2 the table followed the interview structure as presented in chapter D, while applying different styles and colours to highlight important statements or issues.

Figure 5-2: Coding and analysis of unstructured interview data

Node	D10	D16
PART D: Shared language and common vocabulary		
(D1) Have you experienced communication problems based on a different vocabulary or language?	Yes, but not within the virtual team > **client communication > Different perception and interpretation of concepts, items or words**	Yes (In earlier projects) / English language capabilities of French and Spanish people are bad
(D2) Have you experienced difficulties in (sharing and) applying other parties knowledge?	Yes / **The overall knowledge sharing and using process is not a mathematical equation thus a+b=c > tendency to develop new solutions instead of using old ones > Use one's own personal network to get the necessary input / Efficency of knowledge databases less than 30% / Knowledge databases are not used**	No (**Not allowed to share knowledge about outsource deals**) / Our documentation is used by other people / **We don't document issues like how we work or how we do it /**

Source: Developed for this research

The structured parts of the interview data (summary questions) have been coded into numerical form using a similar tabular structure to prepare statistical examination. First, a distribution analysis has been done to reveal and visualise the percentaged agreement/disagreement. In a second step univariate statistical analysis has been carried out, computing the question-related arithmetic mean, standard deviation, variance, minimum and maximum and other indices. Especially during the last phase of the interview analysis (cross-cluster analysis), triangulation was used wherever possible and useful to incorporate many diverse sources of evidence like additional documentation or archival records.

Focusing on quantitative social network data (2) collected using the developed SNA survey the analysis started with a case-by-case investigation reflecting data and findings across all SNA attributes (variables) as defined in appendix E. This more holistic approach has been chosen instead of a SNA attribute-by-attribute proceeding, because the primary approach was to enrich data collection targeting the five defined research issues. Hence, the supplemental use of this methodology was inspired by the aim to visualise communication and knowledge sharing processes as well as to analyse further socio-cultural characteristics of one particular virtual project team. The following

Table 5-1 depicts the maintained case-by-case analysis sequence. The specific order is based on practical suggestions by Cross and Parker (2004) and was streamlined incorporating feedback from two discussion forums (UCINET 2004; SOCNET 2004).

Table 5-1: SNA case-by-case analysis sequence

Step	Analysis issue
	Information and knowledge sharing
1.	Visualisation of project-based *information and knowledge sharing network*.
2.	Analysis of *significant team member characteristics and positions* e.g. central and peripheral graph positions of individuals as well as actors who are prestigious, influential or able to exert information control as a gatekeeper or information broker.
	Additional variable-related characteristics
3.	Identification and analysis of *sub-group structure and strength*.
4.	Investigation of *member-level evaluations* focusing on knowledge awareness, knowledge relevance and cost of bilateral sharing.
5.	Computation of *network density and cohesion* indices.
6.	Calculation of *E-I Index*, hence the balance of internal vs. external [communication/sharing] relationships.
	Cross-variable relationships [4]
7.	Interdependence between (independent) SNA variables and project-related information and knowledge sharing activities: • '*Knowing*' - Thus team members are more likely to seek (and share) knowledge from those whose areas of expertise are known to them. • '*Value*' - Based on the notion that a knowledge seeker positively evaluates the knowledge and skills of the team member sought out in relation to the problem the seeker is attempting to solve. • '*Access*' - It can be expected that a team member's perception of another person's accessibility will affect the decision to seek knowledge from that individual • '*Cost*' – Team members might assess their information and knowledge seeking activities in terms of either interpersonal risks or obligations incurred.
8.	Influence of (control) SNA variables based on collected individual and demographic data on project-related information and knowledge sharing activities: • '*Gender*' – Sex of team member [5] • '*Tenure*' – Length of active membership in project team [6] • '*Proximity*' – Closeness based on team member physical project location • '*Sub-Group'* – Individual membership in formal project-related sub-groups

Source: Developed for this research

In a second step, a pattern analysis has been carried out to reveal possible relationships and/or common themes across cases and attributes. On the operational level a case-related database has been used to structure and store the collected SNA data as well as the computed graphs, matrices and indices. Because of the ethical standards applied during this research two separate data sets have been used. The

[4] Based on studies by Borgatti and Cross (2003)

[5] The control variables 'Gender' and 'Proximity' have been constructed by defining same values (either same gender or same physical location for two team members) as 1 and different values as 0.

[6] The control variable 'Tenure' has been constructed by subtracting the second team member's value (tenure in months) from the first team member's.

first one contained the full participant names and was only used to ease the (internal) analysis process, whereas the second anonymised version was used for (external) reporting purposes. Due to the quantity and complexity of the tool-based analysis output all result matrices (56 per case) have been condensed and indexed to support the efficient identification of individual aspects (variable or actor-related), relationships (between team members and/or variables) and general patterns within each case study setting. Appendix N provides the necessary background information regarding the implemented measures and indices e.g. theoretical basis, interpretive aspects and analysis tool usage. Case-based summaries of calculated measures and indices are shown appendix O, whereas statistical results in numeric form are contained in appendix P and are further elaborated using a graphical format in appendix Q.

A *Cross-Method Synthesis (3)*, as the final part of the analysis strategy, tried to 'marry' the results and findings from the qualitative and quantitative analysis stream, thus providing the necessary information-rich and multi-faceted input targeting the clarification of the research issues as well as focusing on the higher-level research question. During this last fastidious stage of the data analysis the qualitative and the quantitative case-related results have been merged into one data base and arranged adequately to support the researcher during this deductive insight building process. The case environments at large and the interview partners' details are discussed next.

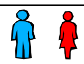
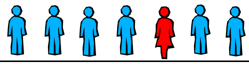
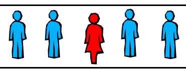
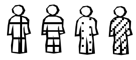
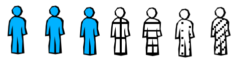
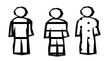
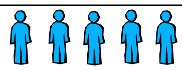
5.3 Case descriptions and participant details

This section provides descriptive data and information about the investigated case studies e.g. project and industry background, team structure and cultural issues. Due to the inherent volume details regarding the interview partners and survey participants are provided in appendix K.

Case A

This case study refers to a joint national development and implementation team targeting the standardisation of a communal tax system. The project team was made-up of 26 multi-disciplinary members belonging to four independent communal computing centres as well as one external IT consulting company. The company is an independent subsidiary of one of the global leaders in IT and part of a corresponding global business network. The team was made up of 96 per cent German nationals and 89 per cent of its members were males. The average tenure for this particular team was 34 months. The following Table 5-2 pictures the overall team structure and geographic distribution.

Table 5-2: Case A - Overall team structure and geographic distribution

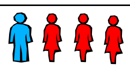
	Geographic location		
Sub-units	City 1	City 2	City 3
Client A			
Client B			
Client C			
IT Consulting Company [7]			
Client D			

Source: Field data

Case B

This case study relates to a decade-old, complex, multi-institutional, multi-disciplinary, multi-site environmental research and development consortium. The organisation's work provides opportunities for exchanging information, developing consensus and managing conflicts at the local, national, regional and global levels. A Global Coordination Office in Nairobi, Kenya assists the consortium with administrative, governance and support functions. The participating eight high level representatives belonged to the Global Steering Group responsible for the strategic development and operational implementation of the future of the consortium. Three staff members from the coordination office acted as control group. Team members represented nine different nationalities with a cultural background of 40% American, 20% African, 20% European and 20% Asian origin (see Table 5-3). Nearly half of the team, thus 45%, was female and the average tenure was 59 months, which is quite long for a project.

Table 5-3: Case B - Overall team structure and geographic distribution

	Geographic location				
Sub-units	Country 1	Country 2	Country 3	Country 4	Country 5
R&D Consortium					

(continued)

[7] The shaded figures represent team members working in several project locations, where each pattern pictures one specific individual.

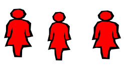
Organisation 1					
Organisation 2					
Organisation 3					
Organisation 4					
Organisation 5					

Source: Field data

Case C

The investigated nationwide distributed team is part of Strategy, Planning and Business Innovation at one of Australia's leading communication providers and represents a number of different functions – Knowledge Management, Intranet strategy and the cultural change team. Altogether there are 14 people in the team, out of those nine participated actively in this case study (see Table 5-4). Although some of the functions have little in common in day to day activities the different sub teams work together to leverage its activities and knowledge, for example working together on strategy and priorities, Communities of Practice and cultural transformation activities. Due to its national business focus the team member's cultural background was quite homogeneous. The following table shows the detailed structure and geographic distribution of the entirely female team. The overall case environment had an average team member tenure of 28 months, whereas the cultural change unit revealed a tenure of around 5 months.

Table 5-4: Case C - Overall team structure and geographic distribution

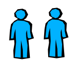
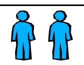
	Geographic location			
Sub-units	City 1	City 2 (a)	City 2 (b)	City 3
Cultural change				
Intranet strategy				
Knowledge Management				

Source: Field data

Case D

This case study refers to a multi project environment targeting pre-sales, consulting and organisational learning activities of one of the leading global IT Service companies. Project E handled the IT integration of an acquired company. The team had to submit a proposal outlining our approach and the associated costs and benefits. Project T represents an up selling opportunity targeting new and extended IT services for an already existing client and is therefore quite important for the company to win. The last Project B handles internal initiatives and sub projects to increase the maturity level of the project organisation e.g. process descriptions, template creation, knowledge sharing. The overall geographic focus of this case study spanned whole Europe and the 16 participants belonged to seven different European nationalities and included one female (see Table 5-5). The average tenure across all three participating project teams was six months.

Table 5-5: Case D - Overall team structure and geographic distribution

	Geographic location [8]										
Sub-units	1 (a)	1 (b)	1 (c)	2 (a)	2 (b)	3 (a)	3 (b)	4	5	6	7
Control Group											
Project E											
Project T											
Project B											

Source: Field data

Case E

The investigated global multicultural team carried out a product development and implementation project targeting new customer-related travel benefits for one of the leading airline alliances. The nine team members represented nine different nationalities with a cultural background of 22% American, 33% European and 44% Asian origin. Two individuals belonged to the alliance headquarters and the remaining seven participants represented one individual member airline each. As depicted in the following Table 5-6 the overall project team included one female member and an average tenure of 31 months.

[8] Numbers indicate different European countries and the letters in brackets show varying cities

Table 5-6: Case E - Overall team structure and geographic distribution

	Geographic location						
Sub-units	Country 1	Country 2	Country 3	Country 4	Country 5	Country 6	Country 7
Airline Alliance HQ							
Airline 1							
Airline 2							
Airline 3							
Airline 4							
Airline 5							
Airline 6							
Airline 7							

Source: Field data

Case F

The last case study is positioned in the engineering and transportation industry and refers to the implementation of a new metro system by one of the worldwide leading international suppliers to the railways industry. In addition to project management and system integration, the team's overall focus lies on the supply of signalling, electrical power, vehicles, and the electromechanical part of the entire project. The project takes place in Asia and has a planned duration of six years with an average tenure for all team members of about 37 months. The 14 participants represent 6 different nationalities with 64% European and 36% Asian cultural background (see Table 5-7).

Table 5-7: Case F - Overall team structure and geographic distribution

	Geographic location		
Sub-units	Country 1	Country 2a	Country 2b
Railway supplier And system integrator			
External Staff			

Source: Field data

After having laid out the individual case environments, the next section will present findings based on the collection and analysis of qualitative data sources.

5.4 Analysis of Interview data (Qualitative)

Case-based as well as individual expert interviews have been carried out and investigated on the basis of a systematic framework and corresponding procedures as described in detail in sub-sections 4.6.3.1 and 4.8.1 of this paper. The analysis is clearly structured around the five research issues, where each part starts with a within-case analysis, followed by a cross-case investigation, relevant findings from individual sources and ends with an issue-based summary. To improve data display and readability tables have been used frequently to present, categorise and contrast appropriate results.

5.4.1 Results and findings regarding the first research issue 'Trust'

Within-case analysis

Regarding the first investigated case study (*Case A*) it came apparent that team members from the client and provider side perceived the quality and development of trust differently, thus 'external' actors seemed to have problems establishing the necessary trustful relationship with members of the client team(s) (see Table 5-8). This qualitative finding was supported by quantitative results computed from summary questions, where client and provider participants show contrary outcomes targeting team member integrity, reliability and team spirit. The analysis of *case B* revealed the relevance of existing strong relationships, thus interpersonal trust, as one important prerequisite for lasting success in virtual project settings. Moreover, the necessity of transparent dealing was highlighted. This statement correlated with findings referring to *case C*, where congruence between team member words and actions was urged. Further findings target the connection of trust with team member relationships and the need for openness and effective communication skills to support the development and sustainability of trust. One interviewee mentioned that without visible support from line managers, the virtual team got de-focused and trust decreased.

Table 5-8: Qualitative data analysis regarding research issue 1 (Trust) – Case-related key findings [9]

	Key findings
Pilot	• Trust is established primarily based on skills and competency [P07]
Case A	• All participants from the client side reported a very cordial atmosphere and an open culture [A18] [A23] • The interviewee from the provider side stressed that development of trust is not happening effectively and only in close interpersonal contact [A20]
Case B	• Strong (existing) personal and business contacts form the important part of success in virtual project settings [B15] [B16] • One should try hard to be transparent in his dealing with other team members [B15] • All interviewees stress that interpersonal trust is the most important form of trust in virtual environments
Case C	• Team member actions and words have to be congruent [C12] • Shared stories about team members can build trust or destroy it [C15] • Openness and ability to communicate effectively is very important [C14] • Line managers are not promoting the work the team is doing > turbulent team development > teams members got de-focused and trust decreased [C11] • Trust is absolutely based on relationships [C15]
Case D	• If team members asked for help early trust was enhanced [D13] • Independently working team members are more trustworthy [D10] • Used his informal contacts to check whether new team members fit into his 'work standards' > if not, he double checked their work results [D13] • First initial interpersonal trust (based on personal impression and/or feedback from informal network) > then task-related trust [D10]
Case E	• Sometimes we trust each other and sometimes we withhold information or knowledge [E15] • Confidentiality is very important [E13] [E15] • Depends on quality and frequency of bilateral communication [E10] • High personal turnover (Airline alliance delegates) > He trusts the airline alliance, but he hardly can trust often changing team members [E15] • Trust is established in a first step by assigning staff from a parent organisation [E13] • The airline network is not one uniform entity > several "trust systems" exists [E10]
Case F	• Type of trust depends on hierarchical level in project organisation > Managers: More Interpersonal > Engineers: More task-related [F10] • Trust based on competence and experience > Primarily task-related, less interpersonal [F14] • There is a difference between interpersonal trust (he is a nice guy) and the task-related trust (he has the competence to do the job) [F23]

Source: Field data

Case D uncovered notions that independently working team members are more trustworthy and the fact that if individuals frankly ask for help, initial barriers could be lowered and trust increased. *Case E* revealed interesting insights because in this project setting political and confidentiality aspects seemed to be very important, thus project partners deliberately withheld information or knowledge. In addition, interviewees reported a hight team member fluctuation and stressed that trust in an early stage derived primarily from organisational membership and to a lesser extent from individual characteristics or competences. Results from summary questions showed that one new Asian team member rated aspects like team member reliability and integrity contrary to the three other 'established' interviewed project members.

[9] The quare brackets reference the individual interviewees according appendix K.

Finally, *case F* unearthed initial evidence that in highly technical environments (e.g. engineering or IT projects) task-related trust is more important than its interpersonal variant and team members focus more on individual competence and experience when assessing the trustworthiness of individuals. One interviewee related the type of trust to hierarchical levels within the project; hence managers favour interpersonal trust and engineers more task-related trust. Next, cross-case findings based on the analysis of interview summary questions will be presented and discussed.

Cross-case analysis

As depicted in Table 5-9 more than 70 per cent of the case participants couldn't' identify different types and levels of trust within their virtual project team or marked the question as not applicable. Further, the majority of interviewees said that they could rely on their team colleagues (Ø 4,25 agreement in a scale from 1 to 5 – see Table 5-9) and supported the notion that the enhancement of trust doesn't happen on its own, but has to be managed proactively (Ø 4,29 agreement). In addition, the analysis showed that, based on interviewee feedback, team member reliability, consistency, and responsiveness enhances the level of trust (Ø 4,58 agreement).

Table 5-9: Qualitative data analysis regarding research issue 1 (Trust) – Cross case examination of interview summary questions [10]

		Disagree		**.............**		**Agree**
	N/a	1 (No)	2	3	4	5 (Yes)
(C2) Can you identify and describe different types and levels of trust in your virtual project team, e.g. task-related vs. interpersonal trust?	25%	46%	-	-	-	29%
(C3) Members of this virtual project team show a great deal of integrity.	0%	0%	8%	8%	54%	29%
(C4) I can rely on those with whom I work in this project team.	0%	0%	4%	4%	54%	38%
(C5) Trust is the primary facilitator focusing in knowledge management in virtual project teams.	0%	0%	25%	25%	33%	17%
(C6) The enhancement of trust does not happen on its own, but depends on a well managed approach.	0%	0%	4%	13%	33%	50%
(C7) We are usually considerate of one another's feelings in this project team.	0%	4%	0%	21%	50%	25%
(C8) There is no "team spirit" in this project team.	0%	58%	25%	8%	8%	0%
(C9) Team member reliability, consistency, and responsiveness enhance the level of trust.	0%	0%	0%	8%	25%	67%

Source: Field data

10 The table displays the overall distribution across the five-stage Likert-style questions ranging from 1 (I totally disagree) up to 5 (I fully agree) as well as the arithmetic mean represented by a (grey) vertical line. Simple Yes/No questions are highlighted using a grey background.

The following paragraph presents findings relating to the first research issue 'trust' extracted from individual expert interviews.

Individual expert interviews

One interviewee linked the aspect of trust with safety feelings, thus "is this team environment a save place for me to disagree or come up with a wild idea?" [Int2][11]. Trust is established via a series of small tests and is build incrementally, thus team members are always probing and testing each other [Int4] and trust enhances, if a strict code of ethics is followed and strict confidentiality rules and procedures maintained [Int5]. In this context, one participant stressed that a direct person-to-person contact is not always necessary, thus trust can be established using acquaintance e.g. via a person's boss or colleague [Int8]. Finally, early findings that task-related trust exists primarily in technical teams could be confirmed [Int10].

Summary regarding research issue 1 (Trust)

The analysis revealed that in technical (or operational) environments task-related trust is more prevalent than its interpersonal form, thus team members focus more on individual competence and experience, when assessing the trustworthiness of individuals. On a more managerial level though, interpersonal trust seems to be the primary from of trust. Good (prior) business or personal relationships are important prerequisites for lasting success in virtual project settings and findings suggest that transparent dealing as well as congruence between a person's words and actions is equally important. The majority of participants rated their project environment as trustworthy, but urged the need for a systematic management approach targeting the enhancement of trust. Moreover reliability, consistency and responsiveness were highlighted as influential promoters of trustful work environments. Findings regarding the second research issue 'Language and Vocabulary' are presented and discussed next.

[11] Indicates the individual interviewee according appendix K

5.4.2 Results and findings regarding the second research issue 'Language and vocabulary'

Within-case analysis

The analysis of the *pilot study* uncovered the fact that interviewees (even in a later stage of the project) perceived the reciprocal awareness of individual expectations, needs and demands as insufficient, which in turn influenced project implementation. Different knowledge levels and in absence of transparency in the highly dynamic project environment as well as a fractured information (documentation) landscape was criticised in *case A*. This qualitative finding was supported by quantitative results derived from summary questions, where client and provider participants rated communication quality and language homogeneity contrary. Referring to *case B* one participant emphasised that communication problems in multicultural and interdisciplinary project environments are common and need to be addressed in a consistent and fast manner (see Table 5-10 for details).

Table 5-10: Qualitative data analysis regarding research issue 2 (Language and vocabulary) – Case-related key findings

	Key findings
Pilot	• 'Sender' wasn't 100% aware of 'receivers' needs and demands [P08] • Different expectations of team members [P07]
Case A	• Knowledge levels of communication partners too different and insufficient transparency within the highly dynamic project [A23] • Documentation at client side not existing or insufficient / Only fractured pieces of information were available [A20]
Case B	• Communication problems (which are common in interdisciplinary and multicultural environments) need to be addressed head-on and solved as quickly as possible [B16] • Synchronous communication like telephone or online chat put additional pressure on participants because of speed and necessary language skills [B14] • None of the interviewees had a problem with knowledge sharing / usage
Case C	• Documented knowledge so bad that it can't used in other projects / New approach: After action reviews in story format during the project [C15] • Received initial training regarding the project contents > Alignment of language and vocabulary [C12] • Team has not explored team members knowledge portfolios yet [C11]
Case D	• Client communication: Different perception and interpretation of concepts, items or words [D10] • English native speakers can better express their ideas and concepts > leadership position within the team [D13] • The overall knowledge sharing and applying process is not a mathematical equation like a+b=c > tendency to develop new solutions instead of using old ones [D10] • One has to be able to analyse the context (language, culture, vocabulary) first and then start communicating [D13]
Case E	• No native speakers > Use a written communication to ensure common understanding [E12] • It took four months to get used to the language and vocabulary [E15] • Asian team members tend to ask only if they really need input, whereas western team members try to get as much in-depth information as possible / Different interpretation of words, issues or concepts > broader description, explanation and discussion is necessary [E13]
Case F	• Communication problems common when working overseas > Let someone else explain it or

(continued)

	do a sketch [F16] • Different vocabularies / Insufficient English language skills / Different meaning (even in documents) [F14] [F23] • We try to marry different sets of knowledge based on the different project locations in America, Europe and Asia [F10]

Source: Field data

In addition, the investigation revealed that synchronous communication activities like meetings, telephone conferences or even online chats put additional pressure on (foreign) participants because of insufficient language skills and 'invisible' cultural norms, hence these team members tend to prefer a more 'secure' asynchronous environment e.g. email. The majority of team members belonging to *case C* noted the context dependence of knowledge and mentioned consecutive problems when applying codified (explicit) knowledge in new project situations. Aspects related to *case D* supported earlier findings targeting language proficiency. In this setting an English native speaker gained a leadership position within the team, partly because of his ability to express his ideas and concepts more eloquently. Further, interviewees named different perceptions and interpretations of concepts, items or words as another obstacle and highlighted the need for context analysis capabilities (language, culture, vocabulary) as important prerequisite for effective client communication. Referring to *case E* one participant said that it took him around four months to get used to the specific project language and vocabulary. Especially in multicultural project settings a broader description, explanation and discussion of used concepts, issues and words is necessary to avoid misinterpretations and subsequent tensions or conflicts. One participant of *case F* again stressed that communication problems, different vocabularies and different meaning are common phenomena when working abroad. This interviewee suggested a repetition of the 'message' by the designated receiver and the usage of sketches as appropriate procedures or tools to control this potential problem. Further evidence could be found that new team members rated the communication as primarily formal and experienced problems regarding knowledge sharing in contrast to the rest of the interviewees. The following paragraph will now present findings regarding language and vocabulary aspects derived from cross-case interview summary questions.

Cross-case analysis

Two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language (see Table 5-11). The feedback regarding difficulties in knowledge sharing and utilisation is more balanced, thus only 42 per cent of the interviewees had negative experiences in this area. Less than half of the interviewees rated their project as a poor communication environment (Ø 2,17 agreement on a scale from 1 to 5) and most participants highlighted the importance of open and honest communication referring effective knowledge generation and sharing (Ø 4,75 agreement). The majority of the participants supported the notion that documented knowledge is sometimes not easy to understand (Ø 3,98 agreement).

Table 5-11: Qualitative data analysis regarding research issue 2 (Language and vocabulary) - Cross case examination of interview summary questions

		Disagree		....		Agree
	N/a	1 (No)	2	3	4	5 (Yes)
(D1) Have you experienced communication problems based on a different vocabulary or language?	0%	33%	n/a	n/a	n/a	67%
(D2) Have you experienced difficulties in (sharing and) applying other parties knowledge?	13%	46%	n/a	n/a	n/a	42%
(D3) Communications are poor.	0%	25%	50%	13%	8%	4%
(D4) In this virtual project team we share a common language - technically as well as personally.	4%	0%	4%	29%	46%	17%
(D5) Communications are primarily formal.	0%	38%	29%	23%	8%	2%
(D6) Open and honest communications support knowledge generation and sharing.	0%	0%	0%	4%	17%	79%
(D7) Sometimes documented knowledge isn't easy to understand.	0%	4%	4%	21%	31%	40%

Source: Field data

Next, results derived from individual expert feedback will be presented.

Individual expert interviews

The analysis confirmed earlier findings that the interpretation of (what individuals might think are) common words or concepts is sometime very challenging [Int2]. One expert wisely said that words and numbers are often not the connecting instrument, but the separating one and that maps (or sketches as another interviewee mentioned) have the potential to provide a common basis [Int9]. The feeling that foreign meeting participants tend to be shy concurred with prior evidence that insufficient language capabilities and different cultural norms influence team member behaviour in particular ways [Int5]. Focusing on multicultural settings, one source explained that sometimes technical experts tend to have problems explaining their approaches to other multicultural, interdisciplinary project members [Int9] and that the understanding of multicultural project staff has to be checked constantly to ensure common ground [Int7] [Int3]. Referring to Asian cultures one individual put in that a ‘Yes’ often means “I am listening” and not “I will do it” and he added that knowledge has to be ‘translated’ to fit into the local context [Int10].

Summary regarding research issue 2 (Language and vocabulary)

Two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language. Focusing on knowledge sharing and utilisation 42 per cent of the interviewees reported negative experiences or problems in this area and simultaneously highlighted the importance of open and honest communication as a necessary prerequisite. More experienced team members stressed that communication problems in multicultural and interdisciplinary project environments are common and need to be addressed in a consistent and fast manner. It came apparent that synchronous communication activities like meetings, telephone conferences or even online chats put additional pressure on (foreign) participants because of existing (poor) language skills and 'invisible' cultural norms.

Moreover, the majority of the interviewees supported the notion that documented knowledge is sometimes not easy to understand. To avoid endless searching of databases or documents new and/or important knowledge (from a project as well as organisational point of view) has to be clearly indicated as such. Further, knowledge, either tacit or explicit, has to be 'translated' to fit into the local context before it can be successfully utilised in a given project environment. To ensure a common understanding regarding norms, language or vocabulary within a multicultural and interdisciplinary project environment, reflective techniques should be used to avoid misinterpretations and potential fragmentation and isolation. Thus, a broader description, explanation and (sometimes deeper) discussion of used concepts, issues and words are necessary. Findings regarding the third research issue 'Informal networks' are presented in the following sub-section.

5.4.3 Results and findings regarding the third research issue 'Informal networks'

Within-case analysis

The investigation of *case A* revealed substantial differences within the project team regarding the judgement of informal networks. Participants from the three client sub-teams characterised informal structures with comments like "could be very dangerous", "knowledge is power mentality" and "the project may suffer", whereas interviewees from the provider side had a more positive attitude or as one team member said "things progress faster and easier". The loss of transparency was an issue in *case B*, where it was suggested to formalise (relevant) informal groups or networks to let them contribute ‘openly’ to project implementation and success. From a safety point of view informal structures were highlighted by one interviewee as useful forums to discuss ones thoughts and ideas before presenting them to the whole group (see Table 5-12 for details).

Table 5-12: Qualitative data analysis regarding research issue 3 (Informal networks) – Case-related key findings

	Key findings
Case A	• Interviewees from client side showed a negative attitude towards informal networks or ‘cliques’ / "Knowledge is Power" mentality [A18] / “Could be very dangerous” and “The project may suffer” [A23] • The participant from provider side rated informal network positive: “Things progress faster and easier” [A20]
Case B	• “You don't know with whom to check out first to discuss ones thoughts and ideas before presenting it to the whole group” [B16] • One will get better results if the overall structure and processes are transparent for everyone, thus informal groups should be formalised [B14] • The consortium's network is relatively strong compared to others networks [B16]
Case C	• All five interviewees rated informal networks as very important • Without informal networks the project becomes in island, not being able to adjust and modify as the organisational environment changes [C11] • Without "informal" knowledge this team couldn't do what they have to do [C13] • Informal networks can be highly beneficial to overcome silos [C15]
Case D	• Get new and valid knowledge via his personal network [D10] • If you have a good network (with key persons) there is no need for F2F meetings [D10] • It is much easier to share knowledge in informal networks, but then this knowledge is not necessarily available to the whole project team [D13]
Case E	• Personal network influences the product > Members will act in favour of trusted individuals [E15] • Informal networks very often communicate only internally, thus the project suffers [E12] • Informal networks provide closer relationships > more communication > shared information and knowledge has a higher quality [E13]
Case F	• All interviewees rated informal networks or groups as very important

Source: Field data

All five interviewees from *case C* rated informal networks as very important and urged that without this "informal" knowledge the team couldn't do what it is intended to do. One team member described informal networks as bridges connecting the project with the organisational surrounding, thus allowing necessary adjustments and modifications as the organisational environment changes. And another participant added that informal networks can be highly beneficial to overcome silos. *Case D* provided insights regarding knowledge management and informal structures insofar as participants emphasised the importance of informal networks as effective and safe knowledge markets. Interviewees simultaneously highlighted the fact that although it is easier to share knowledge in more informal networks, the rest of the formal project team will not necessarily profit from this interchange. *Case E* supported these findings to such an extent as informal groups within a project tend to have a relative hight degree of inward communication and therefore, from a time and energy point of view, the project may suffer. Moreover, one interviewee stressed that according to his experience shared information and knowledge within an informal context has a higher quality and relevance. All participants from *case F* rated informal networks or groups as very important without providing further comments or evidence. Next, results from the cross-case analysis will be presented.

Cross-case analysis

The results showed that 75 per cent of the interviewees felt that they are able to identify informal structures within the project team (see Table 5-13). This result concurs with a disagreement of most participants regarding the statement that it is not possible for an individual to sufficiently identify informal networks (Ø 2,54 agreement on a scale from 1 to 5). Focusing on the question whether formal or informal contacts are more suitable for knowledge sharing a quite balanced feedback, in contrast to individual interviewee statements, prevailed (Ø 3,00 agreement). The majority of participants assessed the formal project as the primary driving force within their project environment and not informal groups or networks (Ø 2,50 agreement).

Table 5-13: Qualitative data analysis regarding research issue 3 (Informal networks) – Cross case examination of interview summary questions

		Disagree		**..............**		**Agree**
	N/a	1 (No)	2	3	4	5 (Yes)
(F1) Can you identify informal networks or groups within this virtual project team?	8%	17%	n/a	n/a	n/a	75%
(F3) It is not possible for an individual team member to sufficiently identify informal networks.	0%	13%	46%	21%	17%	4%
(F4) Informal contacts are much more suitable for effective knowledge sharing than formal ones.	0%	4%	29%	29%	38%	0%
(F5) Informal networks or groups are the primary driving force in virtual project teams.	0%	17%	42%	21%	17%	4%

Source: Field data

Individual expert feedback provided further insights targeting informal networks in virtual project environments and will be presented next.

Individual expert interviews

One interviewee said that the membership in different informal networks is an important asset in virtual teams from a content and process point of view, because people who actively participate in informal networks know how to move ideas around [Int2]. Comparing formal and informal structures another interviewee stressed that informal networks are good for immediate problem solving, but formal networks are better for knowledge transfer; a statement which contradicts earlier findings [Int5]. The same expert suggested that projects should be started and planed with a more formal structure, the tasks distributed and more informal networks should be used to actually solve the tasks.

Summary regarding research issue 3 (Informal networks)

Results showed that 75 per cent of the interviewees claimed that they were able to identify informal structures within the project team. Informal groups or networks represent a safe and secure environment, which can be used by team members as discussion forum for new or risky thoughts and ideas before presenting them to the whole project team. One potential drawback of informal structures is a loss of transparency and knowledge sharing efficiency, because although they can be effective and safe knowledge markets, the rest of the formal project team will not necessarily profit from this gain. Thus in essence, informal "power" is nothing without (adequate) formal control. Therefore it was suggested to formalise (relevant) informal groups or networks to let them contribute 'openly' to project implementation and success, particularly because evidence could be found supporting the notion that shared information and knowledge within an informal context has a higher quality and relevance compared to its formal counterpart. One interviewee described informal networks as bridges connecting the project with the organisational surroundings, thus allowing necessary adjustments and modifications as the organisational environment changes. On the other hand, given the tendency that informal groups within a project setting have a relative hight degree of inward communication and therefore, from a time and energy point of view, the project itself may suffer. The subsequent part exhibits findings related to the fourth research issue, hence boundaries and related aspects.

5.4.4 Results and findings regarding the fourth research issue ‘Boundaries’

Within-case analysis

Interviewee comments referring to *case A* highlighted two different types of potential boundaries. One participant stressed the reluctance of individuals to contact other knowledgeable, but not collocated team members (geographic boundary), whereas another source identified organisation-related grouping or conglomerating of project staff as an obstacle for knowledge sharing activities (structural boundary). These findings coincide with the fact that the F2F contact frequency regarding provider and client team members differs significantly (29 days vs. one day). *Case B* provided evidence that a sole fixation on explicit knowledge transfer, because of geographical constraints, in combination with a lack of joint learning possibilities has negative influence on boundary-spanning knowledge sharing activities.

Table 5-14: Qualitative data analysis regarding research issue 4 (Boundaries) – Case-related key findings

	Key findings
Case A	• Reluctance to contact other (not collocated) team members [A20] • Employer-related grouping of team members [A23]
Case B	• No F2F contact: Documentation of knowledge happens after the generation of knowledge > Negative impact on boundary spanning (team-to-team) knowledge sharing [B15] • Institutional and interdisciplinary boundaries / Keyword "culture": ethnicity and a 'sub-culture of science' [B15]
Case C	• In F2F situations you have a better possibility to establish the necessary context to ensure the ‘correct’ reassembly or arrangement of the shared knowledge [C14] • Different appraisal systems drive people in different ‘silos’ [C11]
Case D	• F2F Kick-off meeting > Development of personal mindset > distinction between people he can trust and people he can't trust [D13]
Case E	• A lot of common sense between Asian members (Similar strategies, no native English speakers) [E15] • Founding members vs. new members > degree of integration differs / Bigger and smaller members > different strategic interests [E10] • More barriers on parent companies side > Strong focus on individual ‘kingdoms’ instead on team-based approaches / Tendency within parent company of being not open regarding project status and progress [E10]
Case F	• Demarcation of responsibilities ensures the control of unique knowledge [F10]

Source: Field data

Findings related to *case C* support the idea that personal proximity facilitates the necessary context building in such a way that the ‘correct’ reassembly and arrangement of shared knowledge is ensured. In addition, one interviewee warned that different appraisal systems drive people in different ‘silos’, fostering mistrust and increased jealousy. *Case D* showed the relevance of F2F meetings as an important environment for conscious and unconscious evaluation and subsequent development of interpersonal trust or distrust. Interview feedback uncovered the fact that the frequency of F2F contact concurred with the individual project phase and situation (Up to four days a week in early stages or crisis situations and later two days on average). Cultural boundaries were an issue in another case setting (*case E*), where Asian members of an airline alliance formed some sort of informal sub-group based on similar strategies, English language skills and cultural background (see Table 5-14). Additional structural boundaries based on length of membership and airline size have been mentioned by another interviewee, resulting in several degrees of integration. One participant belonging to *case F* urged the necessity of clear demarcation of responsibilities to ensure the control of unique knowledge within a virtual project environment. Results derived from interview summary questions will be presented next.

Cross-case analysis

The connection between proximity and the development of trust was highlighted by the fact that the majority of interviewees denied (see Table 5-15) that trust can be build 100 per cent virtually (Ø 2,33 agreement on a scale from 1 to 5). Further, it became clear that knowledge can be best shared in close personal contact with other team members (Ø 3,83 agreement) and that regarding (technical or personal) complex issues team members definitely preferred a direct face-to-face communication instead of a virtual one (Ø 4,41 agreement). Finally, there was evidence that interviewees supported the notion that their project would run smoother (and better project results could be realised) if more face-to-face interaction would be possible (Ø 3,61 agreement).

Table 5-15: Qualitative data analysis regarding research issue 4 (Boundaries) - Cross case examination of interview summary questions

		Disagree	....		Agree	
	N/a	1 (No)	2	3	4	5 (Yes)
(E3) Trust can be build virtually, thus no face-to-face contact is necessary.	0%	33%	25%	21%	17%	4%
(E4) Regarding (technical or personal) complex issues I definitely prefer a direct face-to-face communication instead of virtual communication channels.	0%	4%	4%	4%	21%	67%
(E5) Knowledge can be best shared in close personal contact with other team members.	0%	4%	8%	21%	33%	33%
(E6) This project would run smoother (and better project results could be realised) if more face-to-face interaction would be possible.	4%	4%	25%	8%	25%	33%
(E7) Knowledge can't be stored in data bases.	0%	25%	42%	13%	10%	10%

Source: Field data

Having analysed case-related data sources focusing on the aspect of 'boundaries', individual findings derived from expert interviews will be addressed next.

Individual expert interviews

One expert stressed the difference between people who just do their jobs and boundary spanners who can bring in new and on-demand knowledge from other areas, thus strengthening a project's responsiveness in dynamic and challenging situations [Int9]. The same interviewee highlighted the importance of project managers to be socially connective, thus linking small collocated cliques within the surrounding virtual fabric. One Asian participant mentioned that face-to-face contact is much more important in Asian cultures compared to western cultures and that multicultural project and knowledge initiatives have to consider this difference [Int11].

Summary regarding research issue 4 (Boundaries)

Several types of boundaries could be identified. Geographic boundaries fostered the reluctance of individuals to contact other knowledgeable, but not collocated team members. Moreover, this sort of constraint hinders the necessary context building in such a way that the 'correct' reassembly and arrangement of shared knowledge is disturbed. Cultural boundaries were evident in one case where Asian members formed some sort of informal sub-group based on similar strategies, English language skills and cultural background. Structural boundaries based on membership tenure and company power / influence could be identified in another setting, resulting in several degrees of integration. This finding concurs with evidence that organisation-related grouping or conglomerating of project staff represents an obstacle for effective knowledge sharing activities. The majority of interviewees highlighted the importance of physical proximity (especially in Asian cultures) regarding the development of interpersonal trust as well as focusing on the solution of complex technical or personal issues. It came apparent that there is a clear difference between people who just do their jobs and boundary spanners who can bring in new and on-demand knowledge from other areas, thus strengthening a project's reactiveness in dynamic and challenging situations. Further interviewee comments stressed the importance of project managers to be socially connective, thus linking small collocated cliques within the surrounding virtual fabric, especially in multicultural and interdisciplinary environments. The following part will show and discuss findings regarding the last investigated research issue 'risks'.

5.4.5 Results and findings regarding the fifth research issue 'Risks'

Within-case analysis

Interviewees from the *pilot study* expressed their belief that virtual project settings are more challenging and require more attention than traditional projects. The investigation of participant feedback referring *case A* provided several insights on how knowledge management is actually lived in this multiparty project team. One participant from the provider side revealed that the necessary exchange (codification) of knowledge has not been considered in the project assignment (no clear contractual regulations) and that these activities are therefore viewed as additional, unplanned work. He further said that the client(s) haven't started any action to build up the needed knowledge to operate the new IT system. The knowledge management approach on the client side was limited to the mere management instruction just to make notes (codification) and to ask (sharing). The client sub-teams were viewed by provider representatives as too much specialised and characterised by a "Knowledge is Power" mentality, whereas the provider himself complained less of internal personal interaction and no adequate support processes to foster knowledge generation and sharing. Given the environmental research background of *case B* insecure property rights and misguiding governmental regulations have been perceived by participants as potential risks regarding knowledge transfer (Keyword: Ethical responsibility). Further, it has to be insured that the technical and scientific integrity of codified knowledge 'survives' the translation process in global work settings.

Table 5-16: Qualitative data analysis regarding research issue 5 (Risks) – Case-related key findings

	Key findings
Pilot	• Virtual project teams are more challenging and require more effort than traditional (collocated) projects [P08]
Case A	• Codification of knowledge is perceived as additional work / Necessary codification not considered in project assignment [A20] • Client KM approaches: "You have to ask" or "You have to make notes" [A23] • Provider: Less personal interaction and no adequate support processes / Client: Too much specialised and a "Knowledge is Power" mentality [A20] • Client does not build up the necessary knowledge to operate the new system / No clear contractual regulations [A20]
Case B	• It has to be insured that the technical and scientific integrity 'survives' the translation process in global work settings [B15] • Risk with knowledge transfer: Ethical responsibility because of insecure property rights and misguiding governmental regulations [B14] [B15]
Case C	• 80% of employees are working for the company for more than 10 years > Old fashioned corporate culture > "Not invented here" syndrome [C15] • External consultants want to control the use of their knowledge > "they are trying to control us" [C14] • "Focus on written words limits knowledge transfer" [C11] • More problems regarding knowledge sharing within core team compared to 'external'

(continued)

	parties > ongoing organisational changes > afraid of loosing the job ('survival mentality') [C13] [C14]
Case D	• Each person's "hidden agenda" > "Knowledge is power" mentality [D10] • (Highly visible) internal competition between departments / Power struggles within the organisation [D10] • Extensive use of cc in emails or only verbal communication to leave no traces behind [D10]
Case E	• Some Asian airlines are not very proactive in expressing their opinion (preferably anonymous) or sharing experience [E12] • Case-by-case discussion with top management what to share and what not to share [E15] • Joint briefing before a conference call or F2F meeting to discuss our position [E13] • Project partners internal guidelines sometimes overrule project issues > Knowledge is only shared on a selective basis [E13]
Case F	• Customer wants as much as knowledge as possible > Asian cultures are very keen on getting new knowledge [F23] • Protective behaviour of different divisions [F10] • Sometimes inflexible and stubbornly behaviour of decision makers at corporate head quarter [F14] [F16]

Source: Field data

The analysis of *case C* showed that the teams corporate surrounding was characterised by a static employee structure (80 per cent of the employees are working for the company for more than 10 years) with a resistance to organisational change (see Table 5-16). According to one interviewee the calculated financial risk of losing the companies intellectual capital through retirement equals a sum of 300 Million US$ within the next five years. Another risk was a "survival mentality" of team members, because of the ongoing organisational changes; an issue, which resulted in more problems regarding internal knowledge sharing within the virtual team compared to the exchange with 'external' parties. One interviewee added that a mere focus on written words, thus codification, limits knowledge transfer. Regarding *case D* one interviewee mentioned power struggles within the organisation and a strong internal competition between different departments ("Knowledge is power" mentality), accompanied by the extensive use of cc in emails and 'secure' verbal communication to leave no traces behind.

Case E revealed the notion that several Asian team members are not very proactive in expressing their opinion in public or sharing their project-related knowledge / experience. One identified risk in this particular project environment was the discovery that internal organisational guidelines of involved project partners sometimes overrule project issues and thus influence the realisation of project targets negatively. Most project partners held joint internal briefings before important conference calls or meetings to discuss their strategic position and to decide what knowledge or information to share and what not to share. Focusing on *case F* one participant stressed that Asian customers want as much as knowledge as possible for their money. Thus, contractual regulations with clients not only cover product issues, but also the provision of technological know-how to operate these complex systems. From an internal point of view however, another interviewee mentioned some sort of protective behaviour of different corporate divisions, which hinders not only knowledge sharing activities, but restricts the necessary reactivity in project-related crisis situations. Moreover, several interviewees mentioned the sometimes inflexible and stubborn behaviour of decision makers at corporate headquarters. Next, results originating from the analysis of cross-case summary questions will be presented.

Cross-case analysis

More than two thirds of the interviewees claimed that they were not aware of knowledge losses with respect to their actual project (see Table 5-17), whereas the statement that knowledge is always lost in virtual project teams received a balanced feedback (Ø 3,04 agreement on a scale from 1 to 5). The fact that participants rated collaborative partners as more experienced in certain areas represents one important initiator for project-related knowledge sharing or, in some cases, knowledge theft (Ø 3,55 agreement).

Table 5-17: Qualitative data analysis regarding research issue 5 (Risks) – Cross case examination of interview summary questions

		Disagree		**.............**		**Agree**
	N/a	1 (No)	2	3	4	5 (Yes)
(G3) Are you aware of knowledge losses in the context of this project team?	4%	71%	n/a	n/a	n/a	25%
(G4) The collaborative partner's corporate culture isn't as open as ours (or vice versa).	21%	8%	17%	8%	25%	21%
(G5) Knowledge is always lost in virtual project teams.	0%	13%	25%	17%	38%	8%
(G6) The collaborative partners certainly have a lot more experience than we do in certain areas.	13%	4%	25%	4%	13%	42%
(G7) The project has established clear and efficient procedures to protect each party's knowledge sources.	13%	4%	33%	13%	25%	13%

Source: Field data

The following paragraph presents findings targeting the research issue 'risks' derived from individual expert interviews.

Individual expert interviews

Focusing on knowledge losses one expert stressed that it is more the question of how people are strategically aware of what they are doing with their knowledge and how much attention they are giving this issue in the context of the project team [Int2]. In this context, one interviewee mentioned that, because of a non existing knowledge mindset, it took him one year as responsible project manager to establish the necessary team culture [Int7]. Linking virtual project environments and crisis situations, feedback suggests that very often teams have lost the ability to establish effective crisis communication, hence they start firing emails to each other instead of relying more on social interfacing [Int9]. One important finding targets the notion of several experts that reflective learning is not valued adequately, thus knowledge is lost, because of a primary focus on immediate (task or project-related) problem solving, but neglecting its organisational and long term relevance as ‘fuel’ for organisational learning processes [Int2] [Int5]. Another interviewee added that too much time is spend on documenting and less time is spend on actually applying existing knowledge [Int4]. Targeting Asian (business) cultures one expert revealed the notion that many companies have an internal approval system to support and control important organisational knowledge sources. Further, earlier findings regarding a deliberate disguising of specific information and knowledge to influence project-related decision making, could be supported [Int11].

Summary regarding research issue 5 (Risks)

More than two thirds of the interviewees claimed that they were not aware of knowledge losses with respect to their actual project. One organisation discovered that the financial risk of losing their intellectual capital through retirement equals a sum of 300 Million US$ within the next five years and that no adequate processes are in place to cope with this development. Further, participants revealed that often the necessary exchange (codification) of knowledge has not been considered in the project assignment (no clear contractual regulations) and that these activities are therefore viewed as additional, unplanned work. In multi-institutional and multicultural project settings insecure property rights and misguiding governmental regulations represent an potential risk regarding the ethical side of knowledge transfer (Keyword: Ethical responsibility). Other interviewees stressed that a mere focus on written words, thus codification, limits knowledge transfer and that it has to be insured that the technical and scientific integrity of codified knowledge 'survives' the translation process in global work settings. Several participants said that their parent companies hold joint internal briefings before important conference calls or meetings to discuss their strategic position and to decide what knowledge or information to share and what not to share. On of the prevailing risks identified in most case environments is the fact that reflective learning is not valued and not implemented adequately, thus knowledge is lost, because of a primary focus on immediate (task or project-related) problem solving, however neglecting its organisational and long term importance as 'fuel' for organisational learning processes. After having presented and discussed findings focusing on the primary research issues, the following paragraph will display findings related to additional interview issues and supplemental qualitative data sources, thus fostering different perspectives and valuable insights targeting the research question.

5.4.6 Analysis of supplemental qualitative data sources

The subsequent results have been developed from parts B, H and I of the interview protocol as well as from additional case-related material and are documented in full detail in appendix M.

Findings referring additional interview issues

Interviewees from the *pilot study* urged that in virtual project settings leadership skills of project managers as well as responsiveness and discipline of team members are very important. Another source mentioned that the primary selection criteria for project staff on the client side were 'availability', whereas the IT Provider focused more on technical skills. The investigation of *case A* showed that initial problem solving activities in an early project stage were not very successful and hence daily work was accompanied by a lot of misunderstandings. All case participants urged the need for physical proximity to foster or even enable knowledge exchange. But although distant team members met from time to time to allow face-to-face knowledge transfer, no sustainable knowledge exchange could be established.

Participant feedback from *case B* clearly indicated that interpersonal skills played a dominant role this virtual team. In this context, the consortium hired an external consultant to facilitate the identification and joint discussion of 'virtual compatible' characters and personalities within the project team. Results highlighted the need for timely reaction when an answer or action is required and that working virtually means a lot of (additional) stress for team members. Further, it came apparent that not all forms of knowledge can be shared virtually, thus the sharing of very unstructured knowledge needs personal touch to be effective.

Case C showed that team-based self assessment often doesn't work, because in this particular setting no one got nervous on account of obvious problems, until external feedback. Two offsite kick-off meetings facilitated by a psychologist were held and each of the subsequent meetings (either F2F or virtual) started with a "socialising phase" e.g. talking about the last weekend and asking how everyone is feeling. Meeting time was restricted to one hour to enhance productivity. Interviewees stressed that team members should be able to genuinely ask questions and genuinely listen to other people and that special moderator skills are needed to ensure good virtual communication e.g. telephone conferences or online forums. Participants concluded that there are still a lot of misunderstandings and assumptions that virtual work is the same as collocated one, which is not the case. The detailed analysis of summary questions for this particular case revealed that participant feedback targeting the inclusion of knowledge management in the organisation's overall strategic goals was quite contradictory.

Technical expertise and a more extraverted character were the primary selection criteria for team members in *case D*. Because of a high team member fluctuation, mentoring and the guiding of newcomers to the entry points of the organisational knowledge system, was essential. Participants mentioned that they actually don't document how they work or how they carry out specific tasks. Some interviewees reported that documented knowledge is often old and outdated ("Information graveyards ") and that the search for needed knowledge is very time consuming. As a result knowledge databases are not used and the overall efficiency of these databases was rated as less than 30 per cent. Finally, telephone conferences have been viewed as equally inefficient, because participants tend to work in parallel and thus are not focused and concentrated; a finding, which concurs with similar results in other cases and expert interviews.

Participants belonging to *case E* characterised the ‘ideal’ virtual team member as open minded, proactive, flexible and positive person with good communication skills, being prepared to share greater amounts of knowledge in rare F2F meetings. In addition, interviewees mentioned that knowledge from the project was hard to translate and apply within the individual parent companies because of different management cultures and standards as well as different organisational, business and market contexts. Referring to *case F*, team members have been chosen primarily because of their technical expertise, although one participant asserted that German head quarters selected individuals based more on ‘availability’ and to a lesser extent from a “best person for the job” perspective. Interviewees mentioned good communication skills as important in this multicultural project environment, simultaneously stating that interpersonal (compared to technical) skills are not valued very much in the organisational setting. This aspect coincided with a high personal fluctuation of contact persons and (initial) competence problems at head quarters, resulting in a more or less stressful project climate with poor knowledge sharing, but a strong focus on formal documentation.

The evaluation of individual *expert interviews* revealed further notions and clues with respect to the challenging nature of knowledge management in virtual projects:

- It takes special skills to effectively manage virtual communication and still remain productive and involved [Int4].
- Knowledge can't be separated from its human carrier without loosing some parts of it [Int8].
- Very often people who put the most effort in virtual teams were not rewarded; instead line managers were promoted [Int9].
- One knowledge strategist stressed that people who can't contribute should not be members of the virtual project team [Int5].
- Focusing on Chinese business environments, it is very likely that a well known and trusted individual will be chosen instead of an obviously better qualified person. Knowledge management is a very new concept compared to the old and strong culture of Guanxi [Int11]. [12]
- There is a difference between (project) task and (virtual team) process, which has to be balanced [Int2].
- People must have the chance to establish social relationships and these connections have to be reaffirmed regularly [Int5] [Int8].
- An international known KM expert highlighted the notion that only 5 out of 80 teams were successfully from a virtual teaming point of view, because in these particular teams the technical project manager realised that he can't handle the social leadership role alone (Solution: One deliverables leader and one high trust 'social' leader) [Int9].
- One experienced knowledge manager stated that virtual settings can be as effective as traditional ones, but it takes around three times as long [Int4].

[12] Connections and relationships, known as guanxi, are very important in Chinese culture. The right connections can ensure an attentive audience for proposals and subsequent interactions. Guanxi also incorporates an element of graft, for those who have the connections will often try to profit from them. Guanxi creates interdependency between two parties because favours received must be reciprocated at some future time.

- Constructs, policies and processes from hierarchical structures often doesn't work in virtual team environments [Int9].

The following Table 5-18 provides an overview of relevant case-related findings indicating their distribution (per case and keyword) and intensity in terms of frequency.

Table 5-18: Qualitative data analysis – Additional findings per keywords and source

	Keyword																							
Source	Awareness	Characteristics / Skills	Communication	Context	Cultural change	Discipline	Distance	Facilitation	Interdisciplinary	Knowledge forms	Knowledge	Knowledge exchange	Knowledge generation	Listening	People	Processes	Socialising	Speed	Stress	Technology	Telephone conference	Training	Virtual work	
Pilot study	1	2				1																		**4**
Case A			1				2					1												**4**
Case B		2						1	1	1			1					1	1					**8**
Case C		2			1			1						1	1		1				1		1	**9**
Case D		2		1				1			3				1					1	2			**11**
Case E		1		1								1												**3**
Case F		2					1					1			4			1				1		**10**
Expert Interview		3										1			5	2	2			3	2		5	**23**
	1	**14**	**1**	**2**	**1**	**1**	**3**	**3**	**1**	**1**	**3**	**4**	**1**	**1**	**11**	**2**	**3**	**2**	**1**	**4**	**5**	**1**	**6**	

Source: Field data

Next, results originating from a cross-case investigation of interview summary questions will be presented and discussed.

Results from cross-case summary questions

As depicted in Table 5-19 more than 95 per cent of the interviewees emphasised that focusing on knowledge management in virtual project settings team members have to possess additional socia-cultural and technical skills to perform effectively. The assessment of familiarity of participants with knowledge management as a term and concept showed an average agreement of 3,58 (on a 1 to 5 scale) and most of the interviewees believed in their project teams to have the leadership capability to succeed in knowledge management (Ø 3,79 agreement). Nearly all participants valued their projects as ideal learning environments (Ø 4,67 agreement) and the notion that certain team member characteristics exist that support virtual project work was widely supported (Ø 4,22 agreement). Although evidence could be found that participants were satisfied with virtual project work (Ø 3,79 agreement), a clear (positive) influence of virtual work on individual job-life balance (Ø 2,91 agreement) and increase in productivity (Ø 3,26 agreement) could not be proven.

Table 5-19: Qualitative data analysis – Results from cross-case summary questions

		Disagree		....		Agree
	N/a	1 (No)	2	3	4	5 (Yes)
(B3) I am familiar with "knowledge management" as a term and concept.	0%	0%	4%	42%	46%	8%
(B4) This project team has the leadership capability to succeed in knowledge management.	0%	0%	8%	21%	54%	17%
(B5) What is intangible in projects or organisations is hardly worth measuring.	0%	38%	25%	4%	13%	21%
(B6) Do your (parent) organisation's overall strategic goals include knowledge management explicitly?	8%	8%	13%	17%	38%	17%
(H2) Do you think that additional (e.g. socio-cultural and technical) skills are necessary to be a good performer in a virtual project environment regarding knowledge generation and sharing?	4%	0%	n/a	N/a	n/a	96%
(H4) My work primarily involves completing independent tasks.	0%	25%	25%	27%	23%	0%
(H5) I'm going to learn a lot by being on this project.	0%	0%	4%	0%	21%	75%
(H6) No additional skills are needed in virtual project environments.	0%	58%	21%	8%	13%	0%
(H7) People are on this team because they are competent.	4%	4%	4%	8%	46%	33%
(H8) There are clear character-related team member attributes that supports virtual project work.	4%	0%	0%	13%	50%	33%
(I2) All in all, I am satisfied with virtual project work.	0%	4%	13%	8%	50%	25%
(I3) Since I started working virtually, I have been able to balance my job and personal life.	13%	13%	17%	17%	25%	17%
(I4) Since I started working virtually, my productivity has increased.	4%	8%	4%	38%	46%	0%

Source: Field data

Further results showed that on average each interviewee spend 13,5 hours a week looking for knowledge and meet not-collocated team members approximately every 71 days during joint F2F meetings.

Summary regarding additional qualitative data sources

Nearly all interviewees (95 per cent) emphasised the need for additional socia-cultural and technical *skills* focusing on knowledge management in virtual project environments. In this context, interpersonal skills play a dominant role and participants characterised the 'ideal' virtual team member as open minded, proactive, flexible and positive person with good communication skills, being prepared to share greater amounts of knowledge in rare F2F meetings. Despite this awareness, several interviewees stressed that interpersonal (in contrast to technical) skills are not valued very much in their parent companies or organisations. In some cases specific *selection criteria* for project staff like technical skills or management experience were suppressed by mere ‘availability’ of sometimes underqualified personnel. Evidence could be found that *responsiveness* and *discipline* are important attributes of trusted and well connected team members. Results highlighted the need for timely reaction, when an answer or action is required and showed further, that virtual work, compared to traditional settings, often puts additional stress on team members. All case participants urged the need for *physical proximity* to foster or even enable knowledge exchange. Further, it came apparent that not all sorts or forms of knowledge can be shared virtually, thus the sharing of very unstructured knowledge needs personal touch to be effective. People must have the chance to establish social relationships and these connections have to be reaffirmed regularly.

Focusing on *documented knowledge* it became obvious that this explicit form of knowledge is often old and outdated and that the search for needed knowledge is in many cases very time consuming. This aspect influenced the usage of knowledge databases by team members accordingly and one participant rated the overall efficiency of these databases as less than 30 per cent. Another common tool in virtual work environments - *telephone conferences* – was viewed by many interviewees as equally inefficient, because people tend to work in parallel during longer sessions and hence are not focused and concentrated. Nevertheless, nearly all participants valued virtual projects as ideal learning environments, although some interviewees urged that there are still a lot of misunderstandings and assumptions that *virtual work* is the same as collocated one. Feedback clearly supported the notion that constructs, policies and processes from hierarchical structures often doesn't work in virtual team settings. One experienced knowledge manager stated that virtual settings can be as effective as traditional ones, but it takes around three times as long. And another source added that, based on his consulting experience, only 5 out of 80 teams were successfully from a virtual teaming point of view, because in these particular teams one deliverables leader worked in ‘synergetic symbiosis’ with one high trust 'social' leader.

Next, findings derived from the cross-cluster investigation of qualitative data sources will provide supplemental insights aiming at the identification of general themes, patterns and significant relationships. The subsequent summary integrates the different qualitative analysis streams into one holistic picture.

5.5 Cross-cluster analysis and summary

Based on findings derived from the previous analysis phases a list of significant themes has been tentatively compiled (see Table 5-20 for details). In a second step, these themes have been systematically examined to uncover their relevance and mutual connections focusing on the research issues as well as identified influential categories. Despite the systematic approach it has to be mentioned that the initial selection of themes as well as the subsequent categorisation is prone to conscious or unconscious bias. As shown in Table 5-21 a theme-related frequency and linkage index has been computed, which in combination allowed a better assessment of patterns and relationships. Meaningful findings will be presented next.

Table 5-20: Cross-cluster analysis of qualitative data – List of significant themes

Finding	Description
[a]	Additional skills: Interviewees clearly indicated that additional skills are needed compared to traditional project settings
[b]	Complex environments: Multi institutional and interdisciplinary environments makes virtual work more difficult
[c]	Complex issues: Regarding complex issues most interviewees prefer a direct face-to-face communication instead of virtual (asynchronous) communication channels
[d]	Context: Different perception and interpretation of concepts, items or words based on culture, organisational context and individual skills. Knowledge has to be 'translated' to fit into the local context. Check understanding of multicultural or interdisciplinary project staff (e.g. let the receiver repeat the 'message').
[e]	Discipline: Reliability, consistency and responsiveness represent influential characteristics trustful team members (Words and actions have to congruent)
[f]	Explicit knowledge: Documented knowledge is often old, outdated or inappropriate and it isn't effectively reused in other projects
[g]	KM in Asia (1): Western style knowledge management approaches are quite new in Asian business environments
[h]	KM in Asia (2): Face-to-face contact is much more important in Asian cultures compared to western cultures
[i]	Knowledge sharing & application: Focusing on knowledge sharing and utilisation 42 per cent of the interviewees reported negative experiences or problems
[j]	Language & vocabulary: Two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language
[k]	Language skills: English native speakers can express their ideas and concepts better
[l]	Politics (1): Withholding information or knowledge to influence decisions making
[m]	Politics (2): Knowledge is Power mentality (Political gaming / Informal 'kingdoms' / Job protection / Individual hidden agenda's)
[n]	Processes: Processes and concepts from hierarchical work settings e.g. appraisal systems, are often not adequate for virtual project environments
[o]	Reactiveness: Participants urged the need for a quick response when an answer or action is required
[p]	Synchronous communication: Synchronous communication during face-to-face meetings as well as video / telephone conferences puts additional pressure on participants (Language skills, 'invisible' cultural norms, speed of communication)
[q]	Telephone conferences: Telephone conferences with a greater number of participants (> 10) are often not very efficient (Special moderator skills needed)
[r]	Trust: Managers tend to focus more on interpersonal trust, whereas technical or functional

(continued)

	oriented team members seem to rely more on task-related trust
[s]	Virtual work environments: Virtual project teams are more challenging and require more effort than traditional (collocated) projects.

Source: Field data

Based on its hight frequency index ‘Culture’ represented the most prominent category, followed by ‘Individual characteristics’ and, equally rated, ‘Communication’ and ‘Boundaries’. Further, with an intermediate rating, came ‘Discipline’ and “Risk’ as well as, all equally rated, ‘Trust’, ‘Knowledge sharing’, ‘Skills’ and ‘Virtuality/Proximity’. In more detail, finding [a] revealed that regarding virtual settings additional skills and appropriate team member characteristics modulate the development of individual trust. Focusing on complex issues, effective communication and knowledge sharing seem to be positively linked with the reduction of boundaries, e.g. a shift from virtuality to proximity [c]. Findings [d] and [j] provided evidence that context diversity links the research issues of risk and language/ vocabulary in a negative way, because of an increased probability of misunderstandings and knowledge mismatch. Further, giving the challenging nature of virtual project environments, team member discipline e.g. impersonated by the aspects of reliability, consistency and responsiveness is positively linked with the corresponding development of trust [e] [o].

Table 5-21: Cross-cluster analysis of qualitative data – Determination of frequency and linkage parameters

	RI					Keyword												
Finding	Trust	Language / Vocabulary	Informal Networks	Boundaries	Risk	Communication	Complexity	Context	Culture	Discipline	Individual characteristics	Knowledge sharing	Politics	Processes	Skills	Technology	Virtuality / Proximity	LINKAGE INDEX
a	x					x			x	x	X				x			6
b			x	x			x	x	x				x					6
c				x		x	x					x					x	5
d		x			x			x	x									4
e	x								x	x	X							4
f					x							x				x		3
g				x					x				x					3
h						x			x								x	3
i					x							x		x				3
j		x			x	x												3
k		x				x					x				x			4
l				x	x				x			x	x					5
m	x		x	x	x				x	x	x	x	x					9
n				x				x						x			x	4
o	x								x	x	x							4
p						x					x				x	x	x	5
q						x				x	x				x	x		5
r	x							x			x							3
s		x		x			x			x					x		x	6
FREQUENCY INDEX	5	4	2	7	6	7	3	4	9	6	8	5	4	2	5	3	5	

Source: Developed for this research

Based on the fact, that most international project environments use English as primary language, native speakers tend to be able to express their ideas and concepts more eloquently, thus supporting their influential position within the team [k]. Politics represent one of the greatest obstacle or facilitator in many project environments. The corresponding linkage index proves the complex and mostly 'invisible' nature and further shows the strong interconnectivity referring the investigated research issues e.g. trust, informal network and boundaries, to name a few [m]. Finding [n] advocated the relevance of context-sensitive processes targeting effective knowledge management, thus traditional organisational processes designed for a high proximity work place are often not adequate for virtual and multi-stakeholder project environments. A relationship between the mode of communication and team member stress load revealed finding [p], where participant feedback highlighted an additional pressure on team members during synchronous communication based on language skills, speed of communication and 'invisible' cultural norms.

Linking a team members' hierarchical and functional position with the predominant type of trust, finding [r] supported the idea that managers tend to focus more on interpersonal trust, whereas technical or functional oriented team members seem to rely more on task-related trust. Looking at the bigger picture, analysis findings emphasised that virtual project environments in general are more challenging and require more (individual and organisational) effort than traditional (collocated) projects [s]. Next, relevant findings regarding the multi-faceted analysis of qualitative data sources will be summarised.

Summary qualitative data analysis

Within the context of the chosen analysis strategy the investigation of the collected qualitative data followed a clear issue-by-issue sequence and started with a ***within-case analysis***. Regarding the research issue of *trust* it came apparent that team members from the client and provider side of case A perceived the quality and development of trust differently, thus 'external' individuals seemed to have problems establishing the necessary trustful relationship with members of the core client team(s). In addition, case E revealed interesting insights because in this project setting political and confidentiality aspects seemed to be very important, thus project partners deliberately withheld information or knowledge. In addition, interviewees stressed that trust in an early project stage derived primarily from organisational membership (reputation) and to a lesser extent from individual characteristics or competences.

Focusing on the research issue of *language / vocabulary,* participant feedback from case B showed that communication problems in multicultural and interdisciplinary project environments are not unusual and need to be addressed in a consistent and fast manner. The majority of team members belonging to *case C* urged the context dependence of knowledge and mentioned related problems regarding the application of codified (explicit) knowledge in new and different project situations. Next, targeting *informal networks* the investigation of *case A* revealed substantial differences within the project team regarding the judgement of informal networks. Participants from the three client sub-teams characterised informal structures using mostly negative comments, whereas interviewees from the provider side had a much more positive attitude. The loss of transparency was an issue in *case B*, where it was suggested to formalise (relevant) informal groups or networks to let them contribute 'openly' to project implementation and success.

Several types of *boundaries* could be identified throughout the analysis. Geographic boundaries fostered the reluctance of individuals to contact other knowledgeable, but not collocated team members, thus hindered the necessary context building and disturbed the application of shared knowledge (Case A). Cultural boundaries were evident in case E where Asian members formed some sort of informal sub-group based on similar strategies, English language skills and cultural background. The same setting inhered structural boundaries based on membership tenure and company power / influence, resulting in several degrees of integration. Targeting the research issue of *'Risk'* case B uncovered insecure property rights and misguiding governmental regulations as potential risks regarding inter-institutional knowledge transfer. Further, it has to be insured that the technical and scientific integrity of codified knowledge 'survives' the translation process in global work settings. Case E supported the notion that Asian team members are not very proactive in expressing their opinion in public or sharing their project-related knowledge / experience. In addition, it was found that internal organisational guidelines sometimes overrule project issues and thus hinder project implementation.

The subsequent ***cross-case analysis*** examined each research issue from a broader point of view and incorporated findings from *individual expert interviews*. The analysis revealed that in technical (or operational) environments task-related *trust* is more prevalent than its interpersonal form, thus team members focus more on individual competence and experience, when assessing the trustworthiness of individuals. On a more managerial level though, interpersonal trust seems to be the primary from of trust. Two thirds of the participants experienced communication problems in their virtual projects based on different *vocabulary or language*. Focusing on knowledge sharing and utilisation 42 per cent of the interviewees reported negative experiences or problems in this area and simultaneously highlighted the importance of open and honest communication as a necessary prerequisite. To ensure a common understanding regarding norms, language or vocabulary within a multicultural and interdisciplinary project environment, reflective techniques should be used to avoid misinterpretations and potential fragmentation and isolation.

Informal groups or networks represent a safe and secure environment, which can be used by team members as discussion forum for new or risky thoughts and ideas before presenting them to the whole project team. Results showed that 75 per cent of the interviewees claimed that they were able to identify informal structures within the project team. One potential drawback of informal structures is a loss of transparency and knowledge sharing efficiency, because although they can be effective and safe knowledge markets, the rest of the formal project team will not necessarily profit from this gain, thus in essence, informal “power” is nothing without (adequate) formal control. Several types of *boundaries* could be identified during analysis of qualitative interview data. Geographic boundaries fostered the reluctance of individuals to contact other knowledgeable, but not collocated team members. Cultural boundaries were evident in one case where Asian members formed some sort of informal sub-group based on similar strategies, English language skills and cultural background. Structural boundaries based on membership tenure and company power / influence could be identified in another setting, resulting in several degrees of integration. The majority of interviewees highlighted the importance of physical proximity (especially in Asian cultures) regarding the development of interpersonal trust as well as focusing on the solution of complex technical or personal issues.

More than two thirds of the interviewees claimed that they were not aware of knowledge losses with respect to their actual project. Further, participants revealed that often the necessary exchange (codification) of knowledge has not been considered in the project assignment (no clear contractual regulations) and that these activities are therefore viewed as additional, unplanned work. Other interviewees stressed that a mere focus on written words, thus codification, limits knowledge transfer and that it has to be insured that the technical and scientific integrity of codified knowledge 'survives' the translation process in global work settings. On of the prevailing *risks* identified in most case environments is the fact that reflective learning is not valued and not implemented adequately, thus knowledge is lost, because of a primary focus on immediate (task or project-related) problem solving, however neglecting its organisational and long term importance as ‘fuel’ for organisational learning processes.

Next, the analysis of ***additional qualitative issues and data sources*** derived from parts B, H and I of the interview protocol as well as from additional case-related material provided further insights targeting the nature of virtual project work and related knowledge aspects. 95 per cent of the participants emphasised the need for additional socia-cultural and technical *skills* focusing on knowledge management in virtual project environments. In this context, interpersonal skills played a dominant role and interviewees characterised the 'ideal' virtual team member as open minded, proactive, flexible and positive person with good communication skills, being prepared to share greater amounts of knowledge in rare F2F meetings. Despite this awareness, several interviewees stressed that interpersonal (in contrast to technical) skills are not valued very much in their parent companies or organisations. Team members must have the chance to establish social relationships and these connections have to be reaffirmed regularly. Focusing on *documented knowledge* it became obvious that this explicit form of knowledge is often old and outdated and that the search for needed knowledge is in many cases very time consuming. Nevertheless, nearly all participants valued virtual projects as ideal learning environments, although some interviewees urged that there are still a lot of misunderstandings and assumptions that virtual work is the same as collocated one. Feedback supported the notion that constructs, policies and processes from hierarchical structures often are not appropriate for virtual team settings. One experienced knowledge manager stated that virtual settings can be as effective as traditional ones, but it takes around three times as long. And another source added that, based on his consulting experience, only 5 out of 80 teams were successfully from a virtual teaming point of view, because in these particular teams one deliverables leader worked in 'synergetic symbiosis' with one high trust 'social' leader.

Finally, a ***cross-cluster analysis*** was carried out to highlight general patterns and themes regarding the collected qualitative data. Based on the conducted frequency analysis, 'Culture' represented the most prominent category, followed by 'Individual characteristics' and, equally rated, 'Communication' and 'Boundaries'. Focusing on complex issues, effective communication and knowledge sharing seem to be positively linked with the reduction of boundaries. Further, evidence could be found that context diversity connects the research issues of risk and language/ vocabulary in a negative way, because of an increased probability of misunderstandings and knowledge mismatch. The relevance of context-sensitive processes and procedures was equally supported, because traditional organisational processes designed for a high proximity work place are often not adequate for virtual and multi-stakeholder project environments. Additional participant feedback highlighted the relationship between communication mode and team member stress load, thus synchronous communication can exert additional pressure on team members based on individual language skills, speed of communication and 'invisible' cultural norms. Looking at the bigger picture, analysis findings emphasised that virtual project environments in general are more challenging and require more (individual and organisational) effort than traditional (collocated) projects.

After having summarised findings based on the analysis of qualitative data sources, the next Chapter will present results derived from the implemented case-based social network analysis.

6 RESULTS: SOCIAL NETWORK ANALYSIS (QUANTITATIVE)

6.1 Introduction

"KM is more a way of thinking than the purchase of new technology"
[Anonymous]

This chapter focuses on the analysis of quantitative data sources (Social Network Analysis) and independently continues the investigation into the research question and related research issues. The applied case-by-case analysis sequence starts with an investigation of project-based information and knowledge sharing activities, then additional variable-related characteristics and finally SNA cross-variable aspects will be addressed. To enhance readability and transparency frequent figures and summary tables have been developed to support the analysis and argumentation process.

Based on the used SNA questionnaire (see appendix E) the collected data for each of the seven questions corresponds with one individual variable-related social network. The analysis sequence (see Table 5-1) started with a thorough examination of project-related information and knowledge sharing, thus the focal issue of this dissertation. To support the sometimes challenging visual examination of computed graphs or sociograms, quantitative brokerage measures have been calculated using the UCINET software tool (see appendix N for details) and have been used as supplemental reference. Next, additional variable-related network characteristics have been assessed e.g. analysis of sub-group structure and strength as well as computation of network density and cohesion and E-I Index. Finally two sets of cross-variable relationships have been investigated using a matrix correlation technique (QAP - see appendix N for details).

The first group focused on the interdependence between the independent SNA variables of 'Knowing', "Value', 'Access' and 'Cost' and the dependent variable of project-related information and knowledge sharing. The second group targeted the influence of control variables, thus 'Gender', 'Tenure', 'Proximity' and 'Sub-Group' on the dependent variable. Gender homogeneity and physical proximity are well-established factors affecting communication behaviour (Borgatti & Cross 2003). Referring to the same authors, tenure difference has been included, because newer members should know less and, hence, be less likely to be sought for information and knowledge. To mitigate respondent bias and corresponding accuracy problems focusing on the analysis (visualisation) of project-based information and knowledge exchange, the GetInfo and GiveInfo networks have been merged using an estimate pooling technique (Borgatti & Cross 2003, p. 6). Due to the volume of collected data and the complex SNA methodology only significant findings (with respect to the research issues and research question) will be highlighted and discussed throughout the subsequent section. Nevertheless, all relevant results are presented in appendices O and P.

6.2 Case-by-Case results and findings

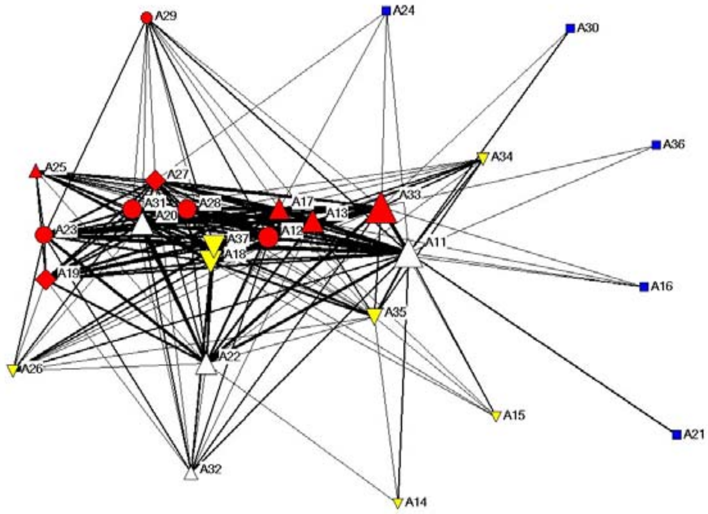
Based on the described analysis sequence the case specific SNA results and findings will be presented and discussed next.

6.2.1 Case A

Information and knowledge sharing

Referring the first analysis stage, thus the visualisation of project-related information and knowledge sharing processes, four graphs have been developed picturing relevant sharing activities from a Degree Prestige, Degree Centrality, Betweenness Centrality as well as Team Member Tenure perspective. The selection of the mentioned indices has been guided by their descriptive and investigative potential (see appendix N for details). Next, a focused discussion of two representative graphs will provide meaningful insights regarding this specific case environment. Figure 6-1 combines the visualisation of information and knowledge exchange with the indication of team members perceived level of prestige. Referring to Table 5-2 the participating organisations or stakeholder are represented by different shapes, whereas the varying geographic locations are highlighted using distinct colours. The graph clearly shows a separation between central and peripheral team members, although it has to be admitted that individuals belonging to 'client C' (blue colour) couldn't actively participate because of political reasons. Giving the fact, that the size of the shapes represents a team members' prestige, two actors, thus 'A33' and 'A11' both belonging to the IT consulting firm, could be identified as most prestigious individuals. Focusing on geographic project locations, it came apparent that the strongest relationships (indicated by line thickness) and prominent sharing activities could be attributed to 'City 2' (red colour).

Figure 6-1: Case A – Visualisation of information and knowledge exchange (Prestige)

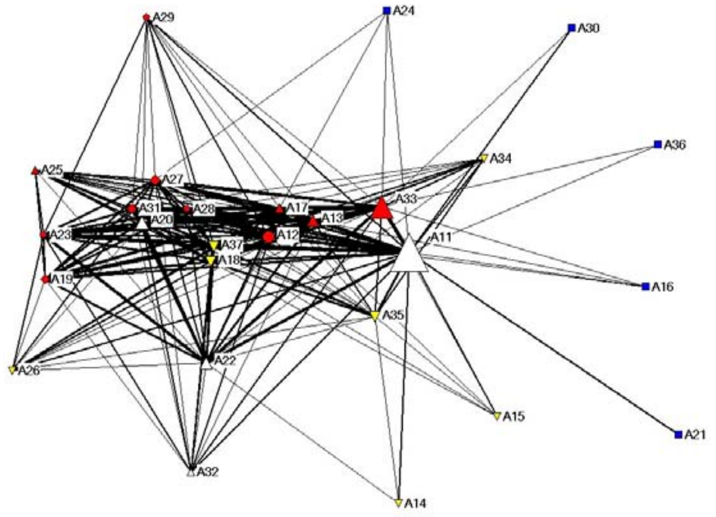


Sub-Unit		Geographic location	
Client A	> 'Diamond'	City 1	
Client B	> 'Down Triangle'	City 2	
Client C	> 'Square'	City 3	
Client D	> 'Circle'	Multiple	
IT Consulting Firm	> 'Up Triangle'		

Source: Developed from field data using UCINET (2004)

The subsequent Figure 6-2 visualises project-related sharing activities from an information control point of view, thus the size of shapes represents the degree of dependency on one particular team member when other individuals have to make connections with other people in this project environment. Thus, networks that contain individuals with high betweenness are vulnerable to having information flows disrupted by power plays or key individuals leaving (Cross & Parker 2004). Concurring with team members 'A11' (Index value 19) and 'A33' (Index value 9) are the most influential and therefore 'critical' actors, followed by 'A20' (Index value 4), 'A22' and 'A13' (Both index values 3).

Figure 6-2: Case A – Visualisation of information and knowledge exchange (Betweenness)



Source: Developed from field data using UCINET (2004)

Given the multiple-stakeholder layout of this case setting a more quantitative investigative procedure as proposed by Gould and Fernandez (1989) has been used to supplement the visual brokerage examination of graphs. Brokerage occurs when, in a triad of nodes A, B and C, A has a tie to B, and B has a tie to C, but A has no tie to C. That is, A needs B to reach C, and B is therefore a broker (see appendix N for details). Table 6-1 shows significant classifications of team members regarding predefined social brokerage roles e.g. ‘A18’ acts as a coordinator and ‘A20’ as a consultant (both individuals also participated in case interviews), whereas team member ‘A28’ functions as a gatekeeper connecting individuals from different network-related sub-groups. Based on the discussion of these brokerage results with key project representatives during a feedback meeting one has to take care not to slip into some sort of pseudo-rational micro-assessment, but always trying to synthesise complemental sources of evidence, thus keeping a holistic perspective.

Table 6-1: Case A - Calculation of brokerage measures focusing on information and knowledge exchange activities

Node	Coordinator	Gatekeeper	Representative	Consultant	Liaison
A12	0,00	0,00	0,00	2,06	1,40
A13	0,00	0,00	1,03	0,52	1,57
A17	0,00	0,00	0,00	0,00	**2,09**
A18	**4,39**	2,06	2,06	0,00	0,35
A19	0,00	0,00	0,00	0,00	**2,09**
A20	0,00	0,00	0,00	**3,28**	0,99
A22	0,00	0,88	0,00	1,77	1,20

(continued)

A27	0,00	0,00	0,00	2,48	1,26
A28	0,00	**6,19**	0,00	0,00	0,00
A31	0,00	0,00	0,00	0,00	**2,09**
A33	0,00	0,00	0,00	**3,10**	1,05
A35	1,65	0,97	**3,48**	0,19	0,39

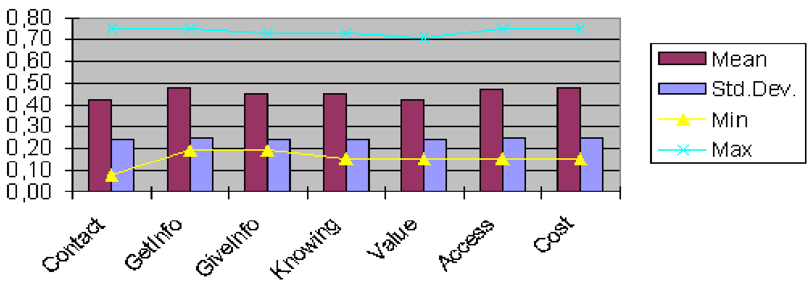
Source: Developed from field data using UCINET (2004)

Targeting known and valued, but inaccessible knowledge sources, the analysis revealed no significant disorders in this particular case environment. After having presented findings referring project-related information and knowledge sharing activities, results derived from additional variable-related attributes will be exhibited next.

Additional variable-related characteristics

Results regarding the analysis of variable-related *sub-group structure and strength* are documented in full detail in appendix O and appendix P respectively. Based on the fact that each variable equals one particular social network, this investigation tried to uncover and assess significant team member groupings (methodological details are provided in appendix N). The sub-group strength varied between 9,83 for the variable 'Contact' and 12,5 for 'GiveInfo' and was quite high compared to a cross-case average of about 6 (see figure 6.3). A visual analysis of sub-group structures and computed structural indices, thus *central and peripheral positions* of team members, provided no additional insights. The investigation of n*etwork density* revealed a lower limit of 0,86 for the variable 'Value' and a upper limit of 1,36 for 'Cost' and the standard variation had a median of 2,3, which is around twice the average density, thus all networks showed a great deal of variation in ties. The distance-based n*etwork cohesion* ranged from 0,774 for the variable 'Contact' up to 0,873 for 'Cost'. All results regarding network density and cohesion are documented in appendix O of this dissertation.

Figure 6-3: Case A – E-I Index per SNA variable



Source: Developed from field data using UCINET (2004)

The last measure utilised in this analysis stage was *E-I index.* This index investigates relationships from a sub-group perspective and is computed by subtracting the number of internal ties from the number of ties external to the groups divided by the total number of ties. Possible scores range from –1 to +1. As the index approaches +1, all the links would be external, whereas a score of –1 would indicate that all links are internal. From a time or energy point of view, one can assume that the more internal links one has, the fewer links one can foster outside a sub-unit (Krackhardt & Stern 1998). Figure 6-3 visualises relevant statistical E-I results referring the implemented SNA variables and shows a quite stable mean across all aspects of about 0,60 with a standard deviation of 0,26. Hence, the five formal sub-units of this project team tend to have increased outward information and knowledge sharing relationships indicating cross-unit collaboration. Next, the relations between variables will be assessed and discussed.

Cross-variable relationships

Regarding the SNA variables of ‘Knowing’, ‘Value’ and ‘Cost’ (Numeric value 0,65 – see Table 6-2 as well as ‘Access’ (Numeric value 0,71) the Pearson index proved structural equivalence focusing on the project-related sharing network, thus these relational aspects are positively connected with information and knowledge exchange in this particular case environment. The average random correlation was zero with a standard error of around 1,25, hence at a typical 0,05 level, these correlations could clearly be considered significant. Nevertheless, it has to be mentioned that the Jaccard coefficient showed high values between 0,62 and 0,97 for average random correlation, therefore was not significant ($p < 0,05$).

Table 6-2: Case A - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,656**	0,000	-0,001	0,125	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,777	0,921	0,786	0,011	0,921	0,147	10.000
Value	Pearson Corr.:	**0,654**	0,000	0,001	0,121	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,752	0,865	0,762	0,012	0,865	0,196	10.000
Access	Pearson Corr.:	**0,712**	0,000	0,002	0,127	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,802	0,620	0,803	0,010	0,620	0,564	10.000
Cost	Pearson Corr.:	**0,654**	0,000	0,000	0,126	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,765	0,967	0,778	0,011	0,967	0,074	10.000
Gender *	Pearson Corr.:	0,141	0,188	0,000	0,157	0,188	0,816	10.000
	Jaccard Coeff.:	0,697	0,306	0,687	0,019	0,306	0,745	10.000
Tenure *	Pearson Corr.:	0,044	0,194	0,000	0,049	0,194	0,806	10.000
	Jaccard Coeff.:	0,761	0,343	0,756	0,013	0,343	0,734	10.000

(continued)

Proximity *	Pearson Corr.:	**0,296**	0,001	0,001	0,078	**0,001**	1,000	10.000
	Jaccard Coeff.:	0,269	0,000	0,223	0,012	0,000	1,000	10.000
Sub-Group *	Pearson Corr.:	**0,225**	0,000	0,000	0,046	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,231	0,000	0,192	0,010	0,000	1,000	10.000

Source: Developed from field data using UCINET (2004)

Focusing on the four examined control variables, only 'Proximity' ($p < 0,05$) and 'Sub-Group' ($p < 0,001$) revealed significant results with a correlation index of 0,296 and 0,225 respectively. These findings suggest that, in contrast to 'Gender' and 'Tenure', both aspects modulate sharing activities in this particular project environment to a certain degree. Next, Table 6-3 summarises key findings derived from the case-related Social Network Analysis.

Table 6-3: SNA – Summary of key findings – Case A

Information and knowledge sharing	
Most prestigious actors [13]	'A33' and 'A11' (Both IT consulting firm) followed by 'A37', 'A20' and 'A13'
Most active actors [14]	'A11', 'A33' followed by 'A17', 'A13', 'A18 and 'A20'
Most influential actors [15]	'A11', 'A33' followed by 'A20', 'A13' and 'A22'
Coordinator role	'A18'
Consultant role	'A20' and 'A33'
Gatekeeper role	'A28'
Representative role	'A35'
Liaison role	'A17', 'A19' and 'A31'
• Focusing on geographic project locations, it came apparent that the strongest relationships and prominent sharing activities could be attributed to 'City 2'. • Based on a feedback meeting with participants care has to be taken not to slip into some sort of pseudo-rational micro-assessment (e.g. referring brokerage measures), but always trying to synthesise complemental sources of evidence, thus keeping a holistic perspective.	
Additional variable-related characteristics	
Sub-group structure/strength	The sub-group strength varied between 9,83 for the variable 'Contact' and 12,5 for 'GiveInfo' and was quite high compared to a cross-case average of about 6. Visual analysis of sub-group structure provided no significant findings.
Central and peripheral positions	Vague knowledge awareness regarding individuals 'A16', 'A21, 'A35', 'A14', 'A15' and great relevance of knowledge of actors 'A25', 'A17', 'A33'. Accessibility of team members 'A21', 'A16', 'A35', 'A14' was limited and sharing of information and knowledge with individuals 'A17', 'A25', 'A19', 'A23' was perceived as comparatively costly.
Network density	Between 0,86 for the variable 'Value' and 1,36 for 'Cost'. The standard variation had a median of 2,3, which is around twice the average density, thus all networks showed a great deal of variation in ties.
Network cohesion	Between 0,774 for the variable 'Contact' and 0,873 for 'Cost'.
E-I Index	Quite stable mean across all SNA variables of about 0,60 with a standard deviation of 0,26. Hence, the five formal sub-units show increased outward information and knowledge sharing relationships indicating cross-unit collaboration.

(continued)

[13] Based on Actor Simple Prestige index

[14] Based on Actor Degree Centrality index

[15] Based on Actor Betweenness Centrality index

Cross-variable relationships
• Structural equivalence based on Pearson index between independent SNA variables (networks) of 'Knowing', 'Value' and 'Cost' as well as 'Access' and the project-related sharing network, thus these relational aspects are positively connected with information and knowledge exchange in this particular case environment. • Jaccard coefficient showed high values between 0,62 and 0,97 for average random correlation, therefore was not significant (p < 0,05). • Focusing on the four examined SNA control variables, only 'Proximity' (p < 0,05) and 'Sub-Group' (p < 0,001) revealed significant results with a correlation index of 0,296 and 0,225 respectively. These findings suggest that, in contrast to 'Gender' and 'Tenure', both aspects modulate sharing activities in this particular project environment to a certain degree.

Source: Developed for this research

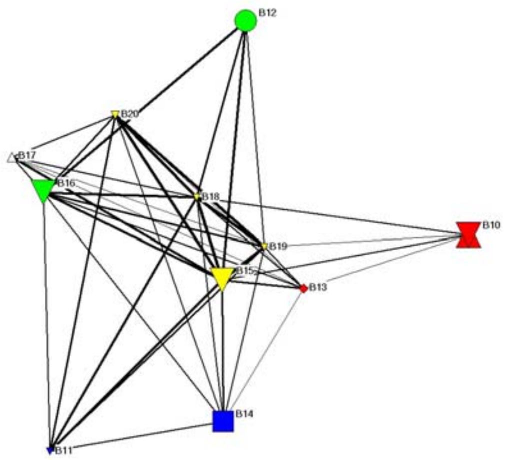
The following sub-section presents findings derived from SNA targeting the second case study, thus case B.

6.2.2 Case B

Information and knowledge sharing

The indication of team member tenure within the project-related information and knowledge sharing network is shown in Figure 6-4. What is evident is the fact that the majority of individuals with a long term membership hold peripheral positions. Further, central positions and strong sharing relationships can be attributed to individuals located in 'Country 1', thus the consortiums headquarters.

Figure 6-4: Case B – Visualisation of information and knowledge exchange (Tenure)

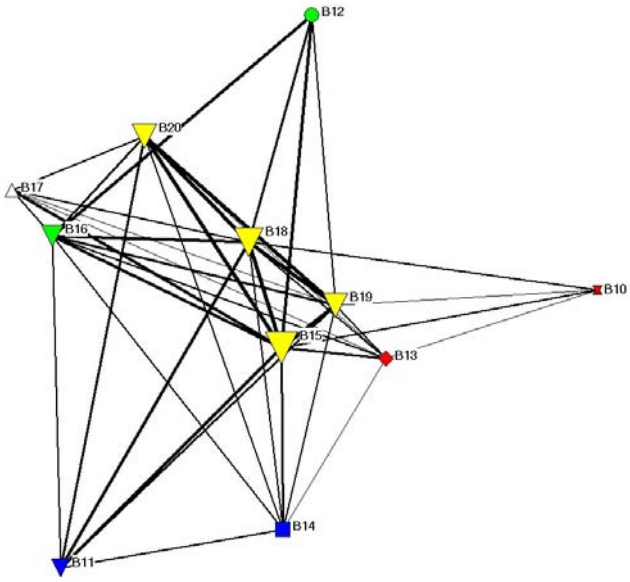


Organisation		Geographic location	
R&D Consortium	> 'Down triangle'	Country 1	
Organisation 1	> 'Up triangle'	Country 2	
Organisation 2	> 'Square'	Country 3	
Organisation 3	> 'Diamond'	Country 4	
Organisation 4	> 'Circle'	Country 5	
Organisation 5	> 'Thing'		

Source: Developed from field data using UCINET (2004)

From a network activity point of view Figure 6-5 displays the most active team members, thus ‘B15’ (Index value 45), ‘B18’ (Index value 39), ‘B19’ (Index value 33), ‘B20’ (Index value 31) and ‘B16’ (Index value 27), embracing whole the R&D consortium’s coordination team. The high level results for these individuals concur with equal outcomes regarding prestige and influence based on the Actor Simple Prestige and Actor Betweenness Centrality index.

Figure 6-5: Case B – Visualisation of information and knowledge exchange (Degree Centrality)



Source: Developed from field data using UCINET (2004)

The quantitative analysis of brokerage roles within the team using UCINET (2004) showed that actor ‘B19’ acted both as a gatekeeper and representative, whereas ‘B12’ provided liaison and team member ‘B13’ a weak consultant functionality (index value 0,73) (see Table 6-4 for details).

Table 6-4: Case B - Calculation of brokerage measures focusing on information and knowledge exchange activities

Node	Coordinator	Gatekeeper	Representative	Consultant	Liaison
B12	0,00	0,00	0,00	0,00	**2,36**
B13	0,00	0,00	0,00	**0,73**	2,10
B19	0,00	**3,30**	**3,30**	0,00	0,00

Source: Developed from field data using UCINET (2004)

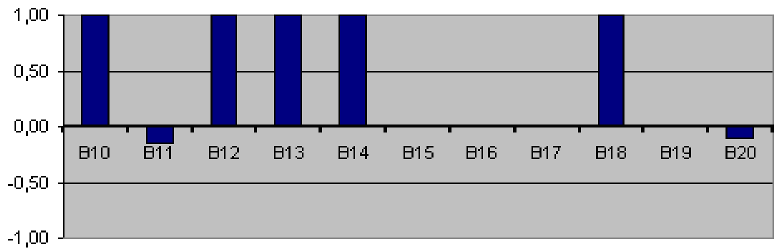
Next, supplemental variable-related attributes will be presented and discussed.

Additional variable-related characteristics

The *sub-group strength* increased from a value of 4,17 for variables 'Contact', 'GetInfo' and 'GiveInfo' up to 5,80-6,00 for the other aspects. Given the inherent complexity of the investigated network data (see appendix O for details) the visual analysis of *sub-group structures* provided no meaningful insights. The examination of *central and peripheral positions* of team members showed that the overall team had only a vague understanding regarding the knowledge repository of 'B12' and that the knowledge of individuals 'B15' and 'B20' was highly valued. In addition, the accessibility of team members 'B10', 'B12', 'B13' and 'B14' was insufficient and communication with actors 'B18', 'B15, and 'B16' was rated as least costly. *Network density* varied between a lower limit of 1,7 for the variable 'Contact', 2,2 for 'GetInfo' / 'GiveInfo' and around 3,3 for the other four aspects. The corresponding standard variation was quite stable across all variables with a median of 2,1, thus indicating an increased variation in relationships. The distance-based n*etwork cohesion* was equally stable within a range of 0,69 for the variable 'GetInfo' up to 0,80 for 'Cost' (see appendix O for details).

The calculation of the *E-I index* derived a more or less fixed numeric value of 0,43 with a high standard deviation of 0,54 for all SNA variables. More compelling is a detailed analysis of this particular index targeting the team-based information and knowledge sharing activities based on a synthesis of variables 'GetInfo' and 'GiveInfo'. Figure 6-6 highlights the degree to which each team member has a more external (+1), internal (-1) or balanced (0) information and knowledge sharing behaviour based on his/her sub-unit membership. In this specific case setting, several sub-units (organisations) had only one member participating in this research (actors 'B10', 'B12', 'B13' and 'B14'), hence for these individuals the calculated E-I index was +1, just because there were no other 'internal' communication partners available. Surprisingly, findings reveal that team member 'B18', belonging to the central coordination team, has only external sharing relationships, but none with colleagues 'B19' and 'B20'.

Figure 6-6: Case B – E-I Index regarding sharing activities



Source: Developed from field data using UCINET (2004)

Next, significant relations between variables will be assessed and discussed.

Cross-variable relationships

The SNA variables of 'Knowing' and 'Value' showed structural equivalence focusing on the project-related sharing network with a Pearson correlation of 0,599 (p < 0,001) and Jaccard coefficient of 0,857 (p < 0,05). 'Access' and 'Cost' revealed an even higher correlation with a Pearson value of 0,686 (p < 0,001) and a Jaccard value of 0,876 (p < 0,05), thus these relational aspects too are positively connected with information and knowledge exchange in this particular case environment (see Table 6-5). The Pearson standard error fluctuated between 0,196 for the first pair of variables and 0,218 for the second one, whereas Jaccard standard error was more or less stable at 0,023.

Table 6-5: Case B - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,599**	0,000	0,003	0,197	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,857	0,024	0,796	0,024	0,024	0,994	10.000
Value	Pearson Corr.:	**0,599**	0,000	0,002	0,196	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,857	0,021	0,796	0,023	0,021	0,995	10.000
Access	Pearson Corr.:	**0,686**	0,000	0,002	0,218	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,867	0,018	0,803	0,023	0,018	0,995	10.000
Cost	Pearson Corr.:	**0,686**	0,000	0,007	0,217	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,867	0,018	0,804	0,023	0,018	0,996	10.000
Gender *	Pearson Corr.:	0,020	0,336	0,000	0,076	0,336	0,691	10.000
	Jaccard Coeff.:	0,461	0,237	0,433	0,029	0,237	0,857	10.000
Tenure *	Pearson Corr.:	-0,012	0,344	0,001	0,029	0,656	0,344	10.000
	Jaccard Coeff.:	0,864	1,000	0,871	0,016	1,000	0,785	10.000
Proximity *	Pearson Corr.:	**0,591**	0,000	0,001	0,135	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,182	0,328	0,161	0,019	0,328	1,000	10.000
Sub-Group *	Pearson Corr.:	**0,756**	0,003	0,001	0,239	**0,003**	1,000	10.000
	Jaccard Coeff.:	0,303	0,213	0,266	0,027	0,213	1,000	10.000

Source: Developed from field data using UCINET (2004)

Referring the four investigated control variables, only ‘Proximity’ (p < 0,001) and ‘Sub-Group’ (p < 0,05) revealed significant results with a correlation index of 0,591 and 0,756 respectively. Based on these findings, it can be suggested that both aspects, in contrast to ‘Gender’ and ‘Tenure’, modulate project-related information and knowledge sharing activities. Next, Table 6-6 summarises key findings derived from the case-related Social Network Analysis.

Table 6-6: SNA – Summary of key findings – Case B

Information and knowledge sharing	
Most prestigious actors	‘B15’, ‘B19’ followed by ‘B20’, ‘B18’ and ‘B16’
Most active actors	‘B15’, B18’, ‘B19’, ‘B20’ and ‘B16’
Most influential actors	‘B15’, B18’, ‘B19’, ‘B16’ (equal values)
Coordinator role	N/a
Consultant role	‘B13’ (weak)
Gatekeeper role	‘B19’
Representative role	‘B19’
Liaison role	‘B12’
• Majority of individuals with a long term membership holds peripheral positions • Central positions and strong sharing relationships can be attributed to individuals located at the consortiums headquarters	
Additional variable-related characteristics	
Sub-group structure/strength	4,17 for variables ‘Contact’, ‘GetInfo’ and ‘GiveInfo’ and 5,80-6,00 for all other variables.
Central and peripheral positions	The examination of central and peripheral positions of team members showed that the overall team had only a vague understanding regarding the knowledge repository of ‘B12’ and that the knowledge of individuals ‘B15’ and ‘B20’ was highly valued. In addition, the accessibility of team members ‘B10’, ‘B12’, ‘B13’ and ‘B14’ was insufficient and communication with actors ‘B18’, ‘B15, and ‘B16’ was rated as least costly.
Network density	1,7 for the variable ‘Contact’, 2,2 for ‘GetInfo’ / ’GiveInfo’ and around 3,3 for the other four aspects. The corresponding standard variation was quite stable across all variables with a median of 2,1, thus indicating an increased variation in relationships.
Network cohesion	The distance-based network cohesion was equally stable within a range of 0,69 for the variable ‘GetInfo’ up to 0,80 for ‘Cost’.
E-I Index	Average value of 0,43 with a high standard deviation of 0,54 for all SNA variables. Detailed analysis of team-based information and knowledge sharing network revealed that team member ‘B18’, belonging to the central coordination team, has only external sharing relationships, but none with colleagues ‘B19’ and ‘B20’.
Cross-variable relationships	
• Significant structural equivalence for independent variables ‘Knowing’ and ‘Value’ (Pearson correlation 0,599) and even higher correlation for ‘Access’ and ‘Cost’ (Pearson value 0,686). • Regarding the control variables, only ‘Proximity’ (p < 0,001) and ‘Sub-Group’ (p < 0,05) revealed significant results with a correlation index of 0,591 and 0,756 respectively, thus it can be suggested that both aspects modulate project-related information and knowledge sharing activities.	

Source: Developed for this research

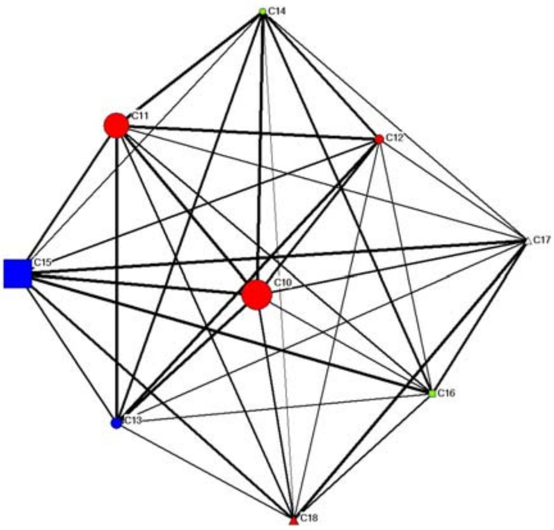
The following sub-section presents findings derived from SNA focusing on the third investigated project team, thus case C.

6.2.3 Case C

Information and knowledge sharing

The subsequent graph (see Figure 6-7) pictures the information and knowledge sharing network of case C highlighting team members individual prestige determined using the Simple Prestige index, whereby ‘C10’, ‘C15’, ‘C11’ and ‘C13’ (in declining order) turn out to the most prestigious actors in this team.

Figure 6-7: Case C – Visualisation of information and knowledge exchange (Prestige)

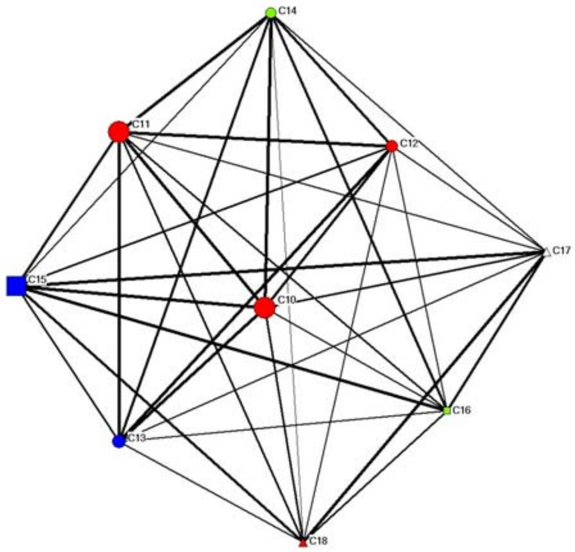


Sub-Team		**Geographic location**	
Cultural change	> ‘Circle’	City 1	
Intranet strategy	> ‘Up triangle’	City 2 (a)	
Knowledge Management	> ‘Square’	City 2 (b)	
		City 3	

Source: Developed from field data using UCINET (2004)

Turning to network activity Figure 6-8 shows the project-related sharing network, where the shape size indicates a team member’s degree of activity computed using the Degree Centrality index. Results point out that individuals ‘C10’, ‘C11’ are the most vivid (or central) ones, followed by ‘C15’, ‘C13’ and ‘C12’. The graph layout is very homogeneous, thus clustering of team members is not detectable based on a visual examination. To support the identification of subgroups a hierarchical clustering technique (see appendix N for details) has been applied and corresponding results will be discussed next.

Figure 6-8: Case C – Visualisation of information and knowledge exchange



Source: Developed from field data using UCINET (2004)

The diagram (see Figure 6-9) re-orders the team members so that they are located close to other actors in similar clusters. The levels indicate the degree of association (similarity) among actors within clusters and the scale at the top gives the level at which they are clustered. The results show three nested partitions, corresponding to rows in the diagram. Within a given row, an 'X' between two adjacent columns indicates that the individuals associated with those columns were assigned to the same cluster in that partition. For example, in the third partition (value 5,500), ‘C10’ and ‘C15’ belong to the same cluster, but ‘C17’ is a member of a different cluster. In the sixth partition (value 3.900), all three team members belong to the same cluster.

Figure 6-9: Case C - Hierarchical clustering on project-related sharing matrix

```
        C C C C C C C C C
        1 1 1 1 1 1 1 1 1
        1 2 3 4 0 5 6 7 8

Level   2 3 4 5 1 6 7 8 9
-----   - - - - - - - - -
6.000   . XXX . XXX . . .
5.750   XXXXX . XXX . . .
5.500   XXXXX . XXX . XXX
4.667   XXXXX . XXXXX XXX
4.313   XXXXXXX XXXXX XXX
3.900   XXXXXXX XXXXXXXXX
2.175   XXXXXXXXXXXXXXXXX
```

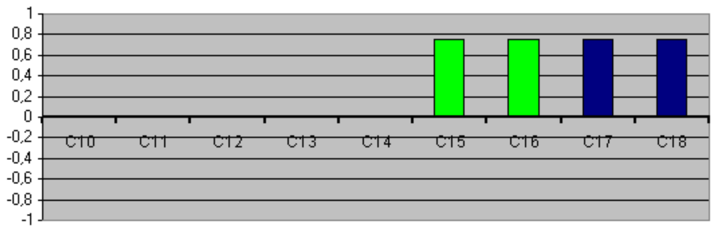
Source: Developed from field data using UCINET (2004)

Thus in essence, the diagram mirrors the formal team structure as depicted in Table 5-4, with the exception that team members ‘C10’ and ‘C15’, belonging to different teams, form a separate ‘sharing cluster’. The additional calculation of brokerage measures provided no results. Next, findings based on the investigation of other variable-related attributes will be presented and discussed.

Additional variable-related characteristics

The *sub-group strength* varied between a lower limit of 5,40 (‘Knowing’) and a upper limit of 6,00 (‘Contact’, ‘GetInfo’ and ‘Cost’). Regarding *central and peripheral positions* of team members, ‘C10’, ‘C11’ and ‘C15’ held central positions in nearly all instances, whereas ‘C13’ and ‘C17’ are often situated at the outer boundaries of the networks. Further, the assessment of actor’s ‘C14’ knowledge capabilities by other team members was quite vague and, in addition, couldn’t be accessed sufficiently. Appendix Q shows the progression of *network density* as well as distance-based n*etwork cohesion* across all variables. Case-related density ranged from 3,06 for ‘Knowing’ (Standard Deviation 1,60) up to 4,64 for ‘Cost’ (Standard Deviation 1,07) and cohesion reached from 0,583 for ‘GetInfo’ to 0,924 for variable ‘Cost’ (see appendix O for numeric details).

Figure 6-10: Case C – E-I Index regarding sharing activities



Sub-Team	
Cultural Change	
Knowledge Management	
Intranet	

Source: Developed from field data using UCINET (2004)

Results derived from the calculation of the *E-I index* focusing on the team-based information and knowledge sharing network are pictured in Figure 6-10. Findings suggest that all members of the cultural change team have a balanced sharing information and knowledge behaviour, thus they have an equal number (E-I index 0) of internal and external relationships. In contrast, both other teams have significantly more external links (E-I index 0,75), which is mainly determined by the comparatively small team size. Next, the relations between SNA variables will be assessed and discussed.

Cross-variable relationships

Focusing on project-related information and knowledge sharing the variables of 'Knowing' ($p < 0,05$), 'Value' ($p < 0,001$) and 'Access' ($p < 0,001$) showed significant structural equivalence with a Pearson correlation index between 0,545 and 0,699 (see Table 6-7) hence these aspects modulate sharing activities in this particular case environment. The Pearson standard error was quite stable within a range from 0,146 ('Value') to 0,149 ('Access').

Table 6-7: Case C - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,545**	0,001	-0,002	0,146	**0,001**	0,999	10.000
	Jaccard Coeff.:	0,958	1,000	0,958	0,010	1,000	1,000	10.000
Value	Pearson Corr.:	**0,581**	0,000	0,000	0,142	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,875	1,000	0,875	0,009	1,000	1,000	10.000
Access	Pearson Corr.:	**0,699**	0,000	-0,001	0,149	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,847	1,000	0,847	0,008	1,000	1,000	10.000
Cost	Pearson Corr.:	0,183	0,074	-0,001	0,151	0,074	0,930	10.000
	Jaccard Coeff.:	0,958	1,000	0,958	0,010	1,000	1,000	10.000
Gender *	Pearson Corr.:	0,000	1,000	3,625	0,036	1,000	1,000	10.000
	Jaccard Coeff.:	1,000	1,000	1,000	0,010	1,000	1,000	10.000
Tenure *	Pearson Corr.:	**0,109**	0,029	0,000	0,056	**0,029**	0,971	10.000
	Jaccard Coeff.:	0,972	1,000	0,972	0,010	1,000	1,000	10.000
Proximity *	Pearson Corr.:	0,107	0,234	-0,001	0,165	0,234	0,783	10.000
	Jaccard Coeff.:	0,222	1,000	0,222	0,002	1,000	1,000	10.000
Sub-Group *	Pearson Corr.:	**0,702**	0,002	0,000	0,165	**0,002**	1,000	10.000
	Jaccard Coeff.:	0,333	1,000	0,333	0,003	1,000	1,000	10.000

Source: Developed from field data using UCINET (2004)

Referring the four investigated control variables, only 'Tenure' ($p < 0,05$) and 'Sub-Group' ($p < 0,05$) revealed significant results with a correlation index of 0,109 and 0,702 respectively. Based on these findings team member gender differences and physical proximity had no significant influence on project-based information and knowledge sharing. Next, Table 6-8 summarises key findings obtained from the case-related Social Network Analysis.

Table 6-8: SNA – Summary of key findings – Case C

Information and knowledge sharing	
Most prestigious actors	'C10', 'C15', 'C11' and 'C13'
Most active actors	'C10', 'C11' (both equal) followed by 'C15', 'C13' and 'C12'
Most influential actors	No significant results (Network centralisation index is zero)
Coordinator role	N/a
Consultant role	N/a
Gatekeeper role	N/a
Representative role	N/a
Liaison role	N/a
• Clustering of team members is not detectable based on a visual graph examination and a hierarchical clustering technique has been used to provide further and deeper insights.	
Additional variable-related characteristics	
Sub-group structure/strength	In essence, team member clustering mirrors the formal team structure, except actors 'C10' and 'C15', which form a separate 'sharing cluster'. Strength varied between a lower limit of 5,40 ('Knowing') and a upper limit of 6,00 ('Contact', 'GetInfo' and 'Cost').
Central and peripheral positions	'C10', 'C11' and 'C15' held central position in nearly all instances, whereas 'C13' and 'C17' are often situated at the outer boundaries of the networks. The assessment of actor's 'C14' knowledge capabilities by other team members was quite vague and, in addition, couldn't be accessed sufficiently.
Network density	Case-related density ranged from 3,06 for 'Knowing' (Standard Deviation 1,60) up to 4,64 for 'Cost' (Standard Deviation 1,07)
Network cohesion	Cohesion reached from 0,583 for 'GetInfo' to 0,924 for variable 'Cost
E-I Index	All members of the cultural change team have a balanced sharing information and knowledge behaviour (E-I index 0), both other teams have significantly more external links (E-I index 0,75), which is mainly determined by their comparatively small team size.
Cross-variable relationships	
• Variables 'Knowing' ($p < 0,05$), 'Value' ($p < 0,001$) and 'Access' ($p < 0,001$) showed significant structural equivalence with a Pearson correlation index between 0,545 and 0,699. • Only 'Tenure' ($p < 0,05$) and 'Sub-Group' ($p < 0,05$) revealed significant results with a correlation index of 0,109 and 0,702 respectively. • Based on these findings team member gender differences and physical proximity had no significant influence on project-based information and knowledge sharing.	

Source: Developed for this research

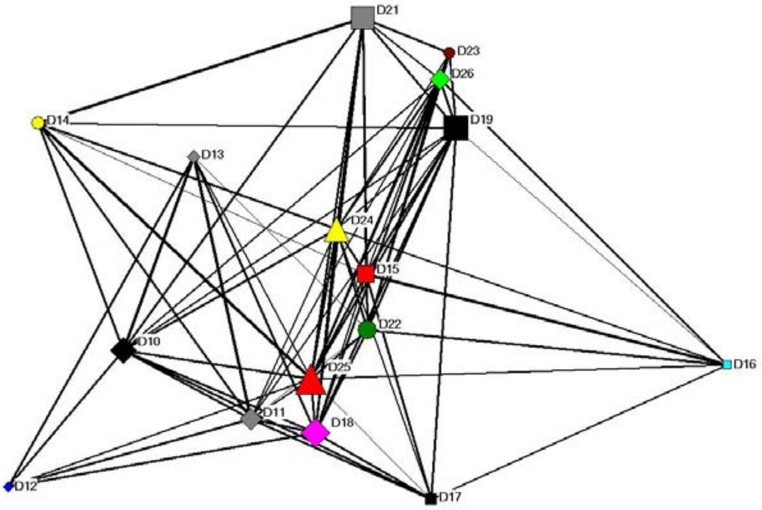
The following sub-section presents findings drawn from SNA focusing on the fourth investigated project team, thus case D.

6.2.4 Case D

Information and knowledge sharing

Team member prestige (indicated by shape size) focusing on within-project as well as cross-project information and knowledge sharing is shown in the following graph (see Figure 6-11). Most valued individuals are 'D25', 'D18', 'D24' and 'D19' (both equal) as well as 'D10', whereby the first four actors all hold central positions and either belong to the coordination team (control group) or are project high-level sponsors. In contrast, 'D10' represents the centre of a sharing community targeting several members of 'Project T'.

Figure 6-11: Case D – Visualisation of information and knowledge exchange (Prestige)



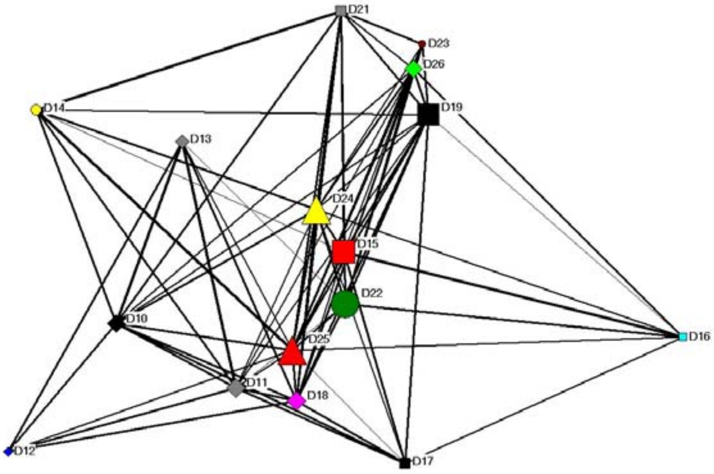
Sub-Unit		Geographic location [16]			
Project B	> 'Circle'	Country 1 (a)	black	Country 3 (a)	red
Project E	> 'Square'	Country 1 (b)	yellow	Country 3 (b)	brown
Project T	> 'Diamond'	Country 1 (c)	cyan	Country 4	light green
Control Group	> 'Up Triangle'	Country 2 (a)	grey	Country 5	magenta
		Country 2 (b)	blue	Country 6	dark green
				Country 7	dark red

Source: Developed from field data using UCINET (2004)

The subsequent graph pictures (see Figure 6-12) a team member's capacity to exercise information control within this multi project environment. Findings suggest that 'D22', 'D24', 'D25' (all equal) followed by 'D15', 'D19' are the most influential individuals. To investigate this aspect further, brokerage measures (see appendix N for details) have been calculated and will be explained next.

[16] Numbers indicate different European countries and the letters in brackets show varying cities

Figure 6-12: Case D – Visualisation of information and knowledge exchange (Betweenness)



Source: Developed from field data using UCINET (2004)

Referring to Table 6-9, results reveal a gatekeeper and representative role for team member ‘D19’ and a consultant function for ‘D13’ and ‘D26’. Further, actors ‘D23’ (sponsor of project B), D24’ and ‘D25’ (both belonging to the coordination team) show a hight degree of liaison functionality.

Table 6-9: Case D - Calculation of brokerage measures focusing on information and knowledge exchange activities

Node	Coordinator	Gatekeeper	Representative	Consultant	Liaison
D13	0,00	0,00	0,00	**5,37**	0,00
D14	0,00	0,00	0,00	1,34	1,94
D15	0,00	0,00	0,00	2,15	1,56
D19	0,00	**1,34**	**2,68**	0,00	0,65
D22	0,00	1,07	0,54	0,00	1,81
D23	0,00	0,00	0,00	0,00	**2,59**
D24	0,00	0,00	0,00	0,00	**2,59**
D25	0,00	0,00	0,00	0,00	**2,59**
D26	0,00	0,00	0,00	**5,37**	0,00

Source: Developed from field data using UCINET (2004)

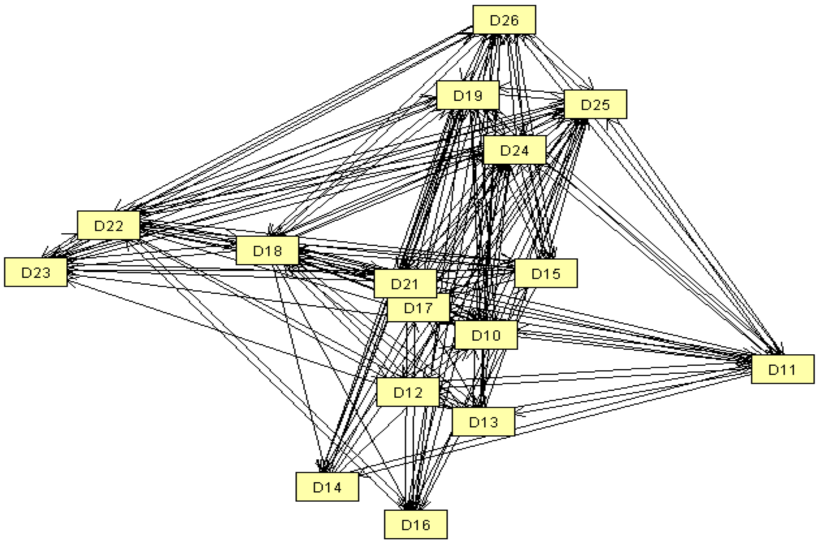
Next, findings based on the investigation of supplemental variable-related attributes will be presented and discussed.

Additional variable-related characteristics

The *sub-group strength* as depicted in appendix Q shows a generally increasing, but irregular progression between a value of 5,66 for ‘GetInfo’ and 9,20 for ‘Access’ and ‘Knowing’. A visual analysis of the *sub-group structure* provided no additional insights.

Regarding *central and peripheral positions* of team members, ‘D11’, ‘D14’, ‘D16’ and ‘D23’ showed limited accessibility (see Figure 6-13), whereas the assessment of actor’s knowledge was quite vague for ‘D12’, D16’, ‘D22’ and especially ‘D26’. Further, the knowledge of team members ‘D18’, ‘D21’ and ‘D24’ was highly valued. *Network density* varied between 1,925 for variable ‘Contact’ and 2,817 for ‘Value’ and *network cohesion* across all variables was comparatively low with a maximum for variable ‘GiveInfo’ (0,622) and a minimum for ‘Access’ (0,555) (see appendix O for details).

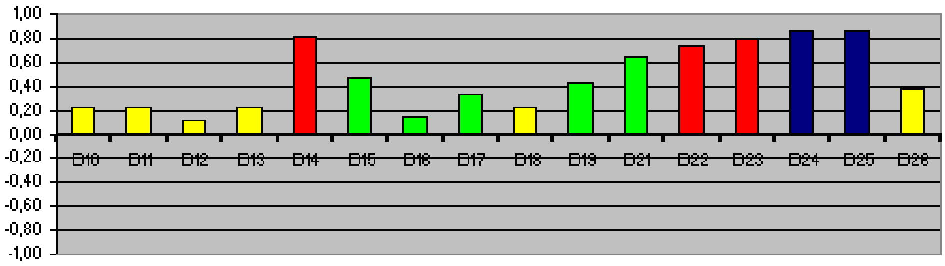
Figure 6-13: Case D – Visualisation of case-related knowledge accessibility



Source: Developed from field data using IKNOW (2003)

Figure 6-14 pictures the calculation of the *E-I index*, thus the assessment of internal vs. external communication links, focusing on individual sub-units. The diagram reveals that members belonging to project T have a higher degree of inward communication, whereas project B and the central coordination team (control group) show a significant external focus.

Figure 6-14: Case D – E-I Index regarding sharing activities



Sub-unit			
Project B		Project T	
Project E		Control Group	

Source: Developed from field data using UCINET (2004)

The following section exhibits results focusing on relationships between the dependent variable of information and knowledge sharing and the four independent and three control variables.

Cross-variable relationships

The correlation analysis revealed significant structural equivalence (p < 0,001) with a Pearson index between 0,755 ('Cost') and 0,814 ('Value'), hence all independent variables positively influence sharing activities in this particular case environment (see Table 6-10). The Pearson standard error was quite low within a range from 0,092 ('Cost') to 0,099 ('Value'). The Jaccard coefficient mirrored these correlation results and showed an even lower average standard error of 0,032.

Table 6-10: Case D - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,811**	0,000	-0,001	0,097	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,840	0,000	0,588	0,032	0,000	1,000	10.000
Value	Pearson Corr.:	**0,814**	0,000	0,000	0,099	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,844	0,000	0,579	0,032	0,000	1,000	10.000
Access	Pearson Corr.:	**0,792**	0,000	0,002	0,098	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,826	0,000	0,586	0,032	0,000	1,000	10.000
Cost	Pearson Corr.:	**0,755**	0,000	-0,001	0,092	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,759	0,000	0,524	0,033	0,000	1,000	10.000
Gender *	Pearson Corr.:	-0.115	0.316	-0.001	0.138	0.747	0.316	10.000
	Jaccard Coeff.:	0,685	0,812	0,715	0,036	0,812	0,251	10.000
Tenure *	Pearson Corr.:	0,001	0,480	0,000	0,024	0,480	0,526	10.000
	Jaccard Coeff.:	0,614	0,957	0,659	0,033	0,957	0,092	10.000
Proximity *	Pearson Corr.:	-0,053	0,291	0,000	0,087	0,731	0,291	10.000

(continued)

	Jaccard Coeff.:	0,031	0,793	0,033	0,008	0,793	0,595	10.000
Sub-Group *	Pearson Corr.:	0,143	0,064	0,000	0,089	0,064	0,938	10.000
	Jaccard Coeff.:	0,258	0,109	0,228	0,022	0,109	0,936	10.000

Source: Developed from field data using UCINET (2004)

None of the calculated measures focusing on the control variables exhibited any significant correlation, thus the aspects of gender, team tenure, physical proximity as well as sub-group membership have no influence on information and knowledge sharing activities in this multi-project environment. Next, Table 6-11 summarises key findings obtained from the case-related Social Network Analysis.

Table 6-11: SNA – Summary of key findings – Case D

Information and knowledge sharing	
Most prestigious actors	'D25', 'D18' then 'D24', 'D19' (both equal) and 'D10'
Most active actors	'D25', 'D18', 'D24' followed by 'D19' and 'D10' (both equal)
Most influential actors	'D22', 'D24', 'D25' (all equal) then 'D15', 'D19'
Coordinator role	N/a
Consultant role	'D13' and 'D26'
Gatekeeper role	'D19'
Representative role	'D19'
Liaison role	'D23', 'D24' and 'D25'
• Most valued individuals either belong to the coordination team (control group) or are project high-level sponsors. • Team member 'D10' represents the centre of a sharing community regarding several members of 'Project T'.	
Additional variable-related characteristics	
Sub-group structure/strength	Generally increasing, but irregular progression between a value of 5,66 for 'GetInfo' and 9,20 for 'Access' and 'Knowing'. A visual analysis of the sub-group structure provided no additional insights.
Central and peripheral positions	Regarding central and peripheral positions of team members, 'D11', 'D14', 'D16' and 'D23' showed limited accessibility, whereas the assessment of actor's knowledge was quite vague for 'D12', D16', 'D22' and especially 'D26'. Further, the knowledge of team members 'D18', 'D21' and 'D24' was highly valued.
Network density	Varied between 1,925 for variable 'Contact' and 2,817 for 'Value'.
Network cohesion	Comparatively low with a maximum for variable 'GiveInfo' (0,622) and a minimum for 'Access' (0,555).
E-I Index	Members belonging to project T have a higher degree of inward communication, whereas project B and the central coordination team (control group) show a primarily external focus.
Cross-variable relationships	
• Significant structural equivalence ($p < 0,001$) with a Pearson index between 0,755 ('Cost') and 0,814 ('Value'), hence all independent variables positively influence sharing activities in this particular case environment. • No significant correlation regarding control variables, thus the aspects of gender, team tenure, physical proximity as well as sub-group membership have no influence on information and knowledge sharing activities in this multi-project environment.	

Source: Developed for this research

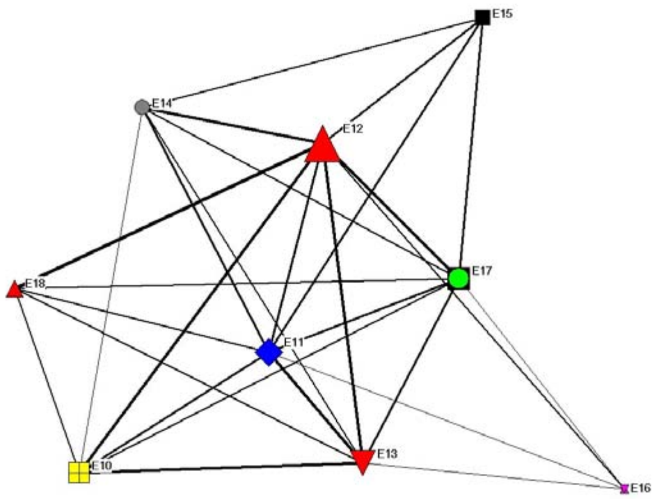
The following sub-section presents findings derived from SNA regarding the fifth investigated project team, thus case E.

6.2.5 Case E

Information and knowledge sharing

The following graph (see Figure 6-15) pictures the team's information and knowledge sharing behaviour highlighting an individual's prestige using different shape sizes. The index is calculated by summing up all actor-related nominations and findings suggest, that team members 'E12', 'E11', 'E13' and 'E17' (in declining order) are the most prestigious ones.

Figure 6-15: Case E – Visualisation of information and knowledge exchange (Prestige)

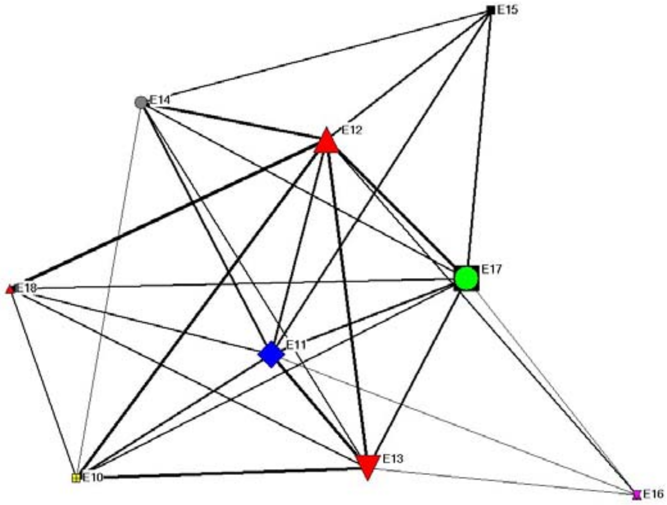


Sub-Unit		Geographic location	
Airline Alliance HQ	> 'Up Triangle'	Country 1	
Airline 1	> 'Down Triangle'	Country 2	
Airline 2	> 'Box'	Country 3	
Airline 3	> 'Diamond'	Country 4	
Airline 4	> 'Square'	Country 5	
Airline 5	> 'Circle'	Country 6	
Airline 6	> 'Thing'	Country 7	
Airline 7	> 'Circle in box'		

Source: Developed from field data using UCINET (2004)

Results from the calculation of degree centrality show that team members 'E12', 'E11', 'E13' and 'E17' (in declining order) are also the most active communicators in this case environment. From an information control perspective actors 'E12', 'E11', 'E13', 'E17' (all equal) followed by 'E14' are most influential (see Table 6-16). Nevertheless, it has to be mentioned that, given the comparatively small team size and high member heterogeneity, this assessment has to be interpreted with care.

Figure 6-16: Case E – Visualisation of information and knowledge exchange (Betweenness)



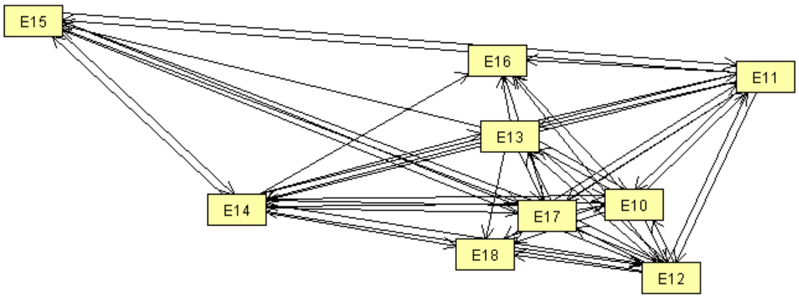
Source: Developed from field data using UCINET (2004)

The supplemental calculation of brokerage measures revealed only a weak liaison role (index value 1,09) for team member ‘E13’, thus this actor supports or facilitates the connection of individuals belonging to different network-related sub-groups. Next, further variable-related distinctive attributes will be presented and discussed.

Additional variable-related characteristics

Sub-group strength indicates the degree of clustering within each variable-based network. This case environment showed a comparatively low strength across all variables ranging from 3,33 for ‘Contact’ up to 5,20 for ‘Value’. The visual analysis of *sub-group structure* provided no additional insights. In contrast, the examination of *central and peripheral positions* of team members, disclosed two separate sharing networks, hence ‘E10’, ‘E11’, ‘E13’ and ‘E12’, ‘E16’, ‘E17’, ‘E18’ focusing on team member’s knowledge accessibility. Figure 6-17 pictures the team-based knowledge awareness and findings suggest that the specific competences and know-how of team member ‘E14’ and especially ‘E15’ are not quite transparent for the rest of the team.

Figure 6-17: Case E – Visualisation of project-related knowledge awareness



Source: Developed from field data using IKNOW (2003)

Regarding the aspect of ‘Value’, actor ‘E12’ holds a central position, hence his knowledge seems to be very important for other team members. In addition, the peripheral position of individual ‘E15’ targeting the variable of ‘Cost’ raise the notion that sharing information or knowledge with this team member is perceived as expensive. *Network density* increased from 1,694 (‘Contact’) up to 3,05 (‘Value’) , whereas *Network cohesion* varied between 0,690 (‘GetInfo’) and 0,840 (‘Cost’) (see appendix O for details). Given the comparatively small team size and high member heterogeneity the calculation of the *E-I index* provided no significant results. Next, relations between different investigated key aspects will be discussed.

Cross-variable relationships

Regarding the SNA variables of ‘Knowing’, ‘Value’ and ‘Cost’ as well as ‘Access’ the Pearson index proved structural equivalence focusing on the project-related sharing network (see Table 6-12), thus these relational aspects are positively connected with information and knowledge exchange in this particular case environment. The average random correlation was zero with a standard error around 0,195, hence at a typical 0,05 level, these correlations could clearly be considered significant.

Table 6-12: Case E - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,627**	0,000	0,000	0,191	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,824	0,042	0,755	0,030	0,042	0,990	10.000
Value	Pearson Corr.:	**0,649**	0,000	-0,001	0,195	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,824	0,041	0,755	0,030	0,041	0,992	10.000
Access	Pearson Corr.:	**0,701**	0,000	0,004	0,208	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,824	0,042	0,755	0,030	0,042	0,990	10.000
Cost	Pearson Corr.:	**0,591**	0,000	-0,002	0,194	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,809	0,046	0,743	0,030	0,046	0,990	10.000

(continued)

Gender *	Pearson Corr.:	0,000	1,000	2,000	0,020	1,000	1,000	10.000
	Jaccard Coeff.:	0,889	1,000	0,889	0,009	1,000	1,000	10.000
Tenure *	Pearson Corr.:	0,015	0,320	0,000	0,031	0,320	0,681	10.000
	Jaccard Coeff.:	0,889	1,000	0,889	0,009	1,000	1,000	10.000
Proximity *	Pearson Corr.:	**0,418**	0,011	0,003	0,211	**0,011**	1,000	10.000
	Jaccard Coeff.:	0,094	0,709	0,083	0,018	0,709	1,000	10.000
Sub-Group *	Pearson Corr.:	**0,591**	0,000	-0,002	0,194	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,809	0,046	0,743	0,030	0,046	0,990	10.000

Source: Developed from field data using UCINET (2004)

Focusing on the four examined control variables, only 'Proximity' ($p < 0,05$) and 'Sub-Group' ($p < 0,001$) revealed significant results with a correlation index of 0,418 and 0,591 respectively. With a numeric value of 0,709 for the Jaccard coefficient regarding 'Proximity' this index contradicts any structural equivalence. In this context, it has to be remembered that this measure is mostly appropriate for low density networks, which none of the analysed projects in retrospect really was. These findings suggest that, in contrast to 'Gender' and 'Tenure', both aspects modulate sharing activities in this particular project environment. Next, Table 6-13 summarises key findings obtained from the case-related Social Network Analysis.

Table 6-13: SNA – Summary of key findings – Case E

Information and knowledge sharing	
Most prestigious actors	'E12', 'E11', 'E13' and 'E17'
Most active actors	'E12', 'E11', 'E13' and 'E17'
Most influential actors	'E12', 'E11', 'E13', 'E17' (all equal) followed by 'E14'
Coordinator role	N/a
Consultant role	N/a
Gatekeeper role	N/a
Representative role	N/a
Liaison role	'E13' (weak)
• Given the comparatively small team size and high member heterogeneity, the calculation of team member influence on information control (Degree Betweenness) has to be interpreted with care.	
Additional variable-related characteristics	
Sub-group structure/strength	Comparatively low strength across all variables ranging from 3,33 for 'Contact' up to 5,20 for 'Value'. The visual analysis of sub-group structure provided no additional insights.
Central and peripheral positions	Focusing on team member's knowledge accessibility two separate clusters, hence 'E10', 'E11', 'E13' and 'E12', 'E16', 'E17', 'E18' could be identified. Specific competences and know-how of team member 'E14' and especially 'E15' are not quite transparent for the rest of the team. Regarding the aspect of 'Value', actor 'E12' holds a central position, hence his knowledge seems to be very important for other team members. The peripheral position of 'E15' targeting the variable of 'Cost' raises the notion that sharing information or knowledge with this team member is perceived as 'expensive'.
Network density	Increased from 1,694 ('Contact') up to 3,05 ('Value')
Network cohesion	Varied between 0,690 ('GetInfo') and 0,840 ('Cost')
E-I Index	Given the comparatively small team size and a high member heterogeneity the calculation of the E-I index provided no significant results.

(continued)

Cross-variable relationships
• Regarding the SNA variables of 'Knowing', 'Value' and 'Cost' as well as 'Access' the Pearson index proved structural equivalence (*p* < 0,001) focusing on the project-related sharing network, thus these relational aspects are positively connected with information and knowledge exchange in this particular case environment. • Focusing on the four examined control variables, only 'Proximity' (*p* < 0,05) and 'Sub-Group' (*p* < 0,001) revealed significant results with a correlation index of 0,418 and 0,591 respectively. These findings suggest that, in contrast to 'Gender' and 'Tenure', both aspects modulate sharing activities in this particular project environment.

Source: Developed for this research

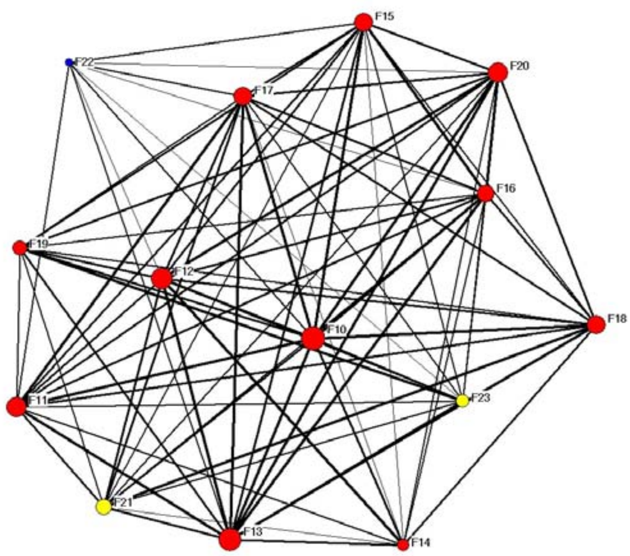
The following sub-section presents findings derived from SNA regarding the sixth and last investigated project team, thus case F.

6.2.6 Case F

Information and knowledge sharing

The investigation of the project-related information and knowledge exchange processes revealed that team members 'F10', 'F13', 'F12', 'F20' and 'F11' (in declining order) are the most prestigious and most active individuals (see Figure 6-18).

Figure 6-18: Case F – Visualisation of information and knowledge exchange (Prestige)



Geographic location	
Country 1	
Country 2a	
Country 2b	

Source: Developed from field data using UCINET (2004)

In congruence with case C the graph layout for this setting was very homogeneous, thus clustering of team members was not detectable based on a visual examination. To support the identification of subgroups a hierarchical clustering technique (see appendix N for details) has been applied. The levels indicate the degree of association (similarity) among actors within clusters and the scale at the top gives the level at which they are clustered. The results show five nested partitions, corresponding to rows in the diagram. In the first partition (value 6,000), team members ‘F10’ and ‘F11’ (technical and commercial project directors) form the primary cluster, which then enlarges step-by-step (see Figure 6-19). In the sixth partition (value 4,4340), this group comprises in total eight individuals, nearly all belonging to the same formal sub-unit of the organisation.

Figure 6-19: Case F - Hierarchical clustering on project-related sharing matrix

```
         F F F F F F F F F F F F F F
         2 1 1 1 1 1 1 1 1 2 1 2 1 2
         2 4 0 1 7 5 2 3 6 0 8 1 9 3

         1                 1   1 1 1
 Level   3 5 1 2 8 6 3 4 7 1 9 2 0 4
------   - - - - - - - - - - - - - -
6.0000   . . XXX . . XXX XXX . . . .
5.7222   . . XXX . . XXXXXXX . . . .
5.5000   . . XXXXX . XXXXXXX XXX . .
5.2500   . . XXXXX . XXXXXXX XXX XXX
4.6667   . . XXXXX XXXXXXXXX XXX XXX
4.4340   . . XXXXXXXXXXXXXXX XXX XXX
3.4735   . . XXXXXXXXXXXXXXXXXXX XXX
2.3126   . XXXXXXXXXXXXXXXXXXXXX XXX
1.8902   . XXXXXXXXXXXXXXXXXXXXXXXXX
0.6167   XXXXXXXXXXXXXXXXXXXXXXXXXXX
```

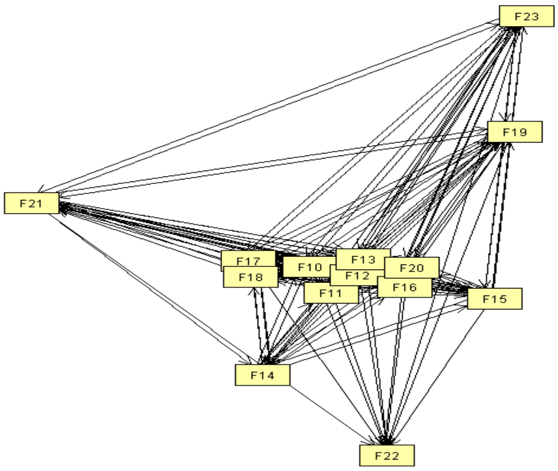
Source: Developed from field data using UCINET (2004)

The quantitative analysis of brokerage roles utilising UCINET (2004) showed that team member ‘F21’ as well as ‘F23’ hold strong (index value 16,55) liaison roles, thus these actors support or facilitate the connection of individuals belonging to different sub-groups of the sharing network. Next, findings based on the investigation of other variable-related attributes will be presented and discussed.

Additional variable-related characteristics

The *sub-group strength* across variables was quite stable between a lower limit of 5,00 ‘(GiveInfo’) and an upper limit of 6,00 (‘Cost’). The visual analysis of *sub-group structures* in variable matrices (networks) provided no additional insights. Focusing on *central and peripheral positions* of team members, the project-related contact network revealed peripheral places for team members ‘F21’, ‘F22’, ‘F23’ and, to a lesser extent, ‘F14’, ‘F15’ an ‘F19’ (see Figure 6-20 for details). Further results suggested, that knowledge awareness was relatively vague for individuals ‘F22’, ‘ F14’, ‘F18’, ‘F16’, ‘F20’ and that the knowledge of actors ‘F10’, ‘F12’, ‘F13’ as well as ‘F18’ had great relevance for the majority of case participants. Graph analysis proved that accessibility of team members ‘F15’, ‘F16’, ‘F19’, ‘F23’ was limited and that sharing information and knowledge with individuals ‘F15’, ‘F16’, ‘F18’, ‘F22’ was perceived as comparatively costly.

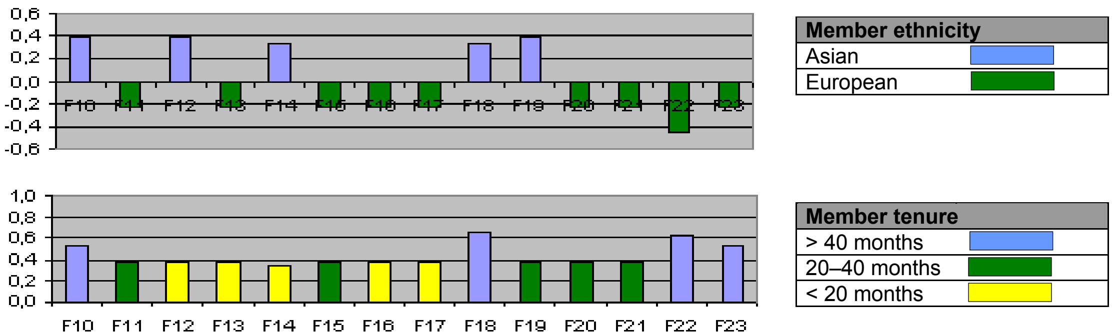
Figure 6-20: Case F – Visualisation of project-related contact network



Source: Developed from field data using IKNOW (2003)

The progression of *network density* was relatively stable ranging from 3,039 for ‘Access’ up to a level of 3,753 for ‘Cost’. Cross-variable *network cohesion* varied between 0,643 (‘GetInfo’) and 0,807 ‘(‘Cost’) with a local maximum for ‘Knowing’. The calculation of the *E-I index* focusing on team member’s ethnicity and tenure (see Figure 6-21 for details) showed for the first aspect a significant different balance regarding internal vs. external sharing links.

Figure 6-21: Case F – E-I Index focusing on team member ethnicity and tenure



Source: Developed from field data using UCINET (2004)

With a value between 0,3 and 0,4 Asian members reveal a more external focus, whereas European project members exhibit a more internal oriented communication with an average index of –0,22 (see appendix N for methodological details). Further, the results support the notion that . Next, findings based on cross-variable characteristics will be presented and discussed.

Cross-variable relationships

The SNA variables of ‘Knowing’, ‘Value’ and ‘Cost’ showed structural equivalence focusing (see Table 6-14) on the project-related sharing network with a Pearson correlation of around 0,650 (p < 0,001). ‘Access’ revealed an even higher correlation with a Pearson value of 0,725 (p < 0,001), thus this relational aspect too is positively connected with information and knowledge exchange in this particular case environment. The Pearson standard error averaged at 0,160 for all four aspects and the Jaccard coefficient proved correlation (p < 0,05) with values between 0,939 (‘Acess’ / ‘Cost’) and 0,950 (‘Knowing’).

Table 6-14: Case F - Correlation analysis – SNA cross-variable influence on project-related information and knowledge sharing

* Control variables		Value	Signif	Avg	SD	P(Large)	P(Small)	NPerm
Knowing	Pearson Corr.:	**0,651**	0,000	0,000	0,163	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,950	0,031	0,931	0,011	0,031	0,997	10.000
Value	Pearson Corr.:	**0,647**	0,000	0,002	0,159	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,944	0,006	0,915	0,011	0,006	1,000	10.000
Access	Pearson Corr.:	**0,725**	0,000	-0,001	0,164	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,939	0,009	0,910	0,011	0,009	0,999	10.000
Cost	Pearson Corr.:	**0,637**	0,000	0,000	0,156	**0,000**	1,000	10.000
	Jaccard Coeff.:	0,939	0,045	0,920	0,011	0,045	0,995	10.000
Gender *	Pearson Corr.:	0,000	1,000	3,362	0,034	1,000	1,000	10.000
	Jaccard Coeff.:	0,973	1,000	0,972	0,010	1,000	1,000	10.000
Tenure *	Pearson Corr.:	0,009	0,384	0,000	0,022	0,384	0,617	10.000
	Jaccard Coeff.:	0,885	1,000	0,889	0,012	1,000	0,696	10.000
Proximity *	Pearson Corr.:	-0,157	0,254	0,002	0,228	0,749	0,254	10.000
	Jaccard Coeff.:	0,577	1,000	0,594	0,015	1,000	0,225	10.000
Sub-Group *	Pearson Corr.:	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Jaccard Coeff.:	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: Developed from field data using UCINET (2004)

None of the calculated measures focusing on the control variables exhibited any significant correlation, thus - based on these findings - the aspects of gender, team tenure (see contradictory E-I results discussed in last paragraph), physical proximity as well as sub-group membership have no influence on information and knowledge sharing activities in this multi-project environment. Next, Table 6-15 summarises key findings obtained from the case-related Social Network Analysis.

Table 6-15: SNA – Summary of key findings – Case F

Information and knowledge sharing	
Most prestigious actors	'F10', 'F13', 'F12', 'F20' and 'F11'
Most active actors	'F10', 'F13', 'F12', 'F20' and 'F11'
Most influential actors	No significant results
Coordinator role	N/a
Consultant role	N/a
Gatekeeper role	N/a
Representative role	N/a
Liaison role	'F21' and 'F23' (both very strong)
• Very homogeneous graph layout. • Hierarchical clustering technique revealed five nested sharing clusters, which in many parts coincide with the formal project structure and corresponding roles.	
Additional variable-related characteristics	
Sub-group structure/strength	Quite stable between a lower limit of 5,00 '(GiveInfo') and an upper limit of 6,00 ('Cost'). The visual analysis of sub-group structures provided no additional insights.
Central and peripheral positions	Vague knowledge awareness regarding individuals 'F22', ' F14', 'F18', 'F16', 'F20' and great relevance of knowledge of actors 'F10', 'F12', 'F13' as well as 'F18'. Accessibility of team members 'F15', 'F16', 'F19', 'F23' was limited and sharing of information and knowledge with individuals 'F15', 'F16', 'F18', 'F22' was perceived as comparatively costly.
Network density	Relatively stable ranging from 3,039 for 'Access' up to a level of 3,753 for 'Cost'
Network cohesion	Varied between 0,643 ('GetInfo') and 0,807 '('Cost') with a local maximum for 'Knowing'
E-I Index	Asian members reveal a more external sharing focus, whereas European project members exhibit a more internal oriented communication behaviour. Individuals with a longer membership have a significant higher external sharing focus compared to newer project members.
Cross-variable relationships	
• All SNA variables showed significant structural equivalence (*p* < 0,001) focusing on the project-related sharing network. Jaccard coefficient proved this correlation (*p* < 0,05) with values between 0,939 ('Acess' / 'Cost') and 0,950 ('Knowing'). • None of the calculated measures focusing on the control variables exhibited any significant correlation, thus - based on these findings - the aspects of gender, team tenure (in contrast to prior E-I results), physical proximity as well as sub-group membership have no influence on information and knowledge sharing activities in this multi-project environment.	

Source: Developed for this research

Having presented and discussed the six case studies from an individual perspective the following section exhibits findings derived from an investigative cross-case approach highlighting significant patterns, themes and relationships.

6.3 *Pattern analysis and summary*

To allow for a better readability and transparency this section has been structured based on

Table 5-1 hence the general case-by-case analysis sequence and starts with a focus on project-based sharing activities, then additional variable-related characteristics and finally SNA cross-variable aspects.

Information and knowledge sharing

One of the most common areas of utilisation for SNA is the investigation of similarities and dissimilarities between the formal organisational structure and the, mostly invisible, informal layer behind it. Table 6-16 pictures the informal assessment of participants' prestige, activity and influence and compares it with their generic formal team functions, thus leadership, member and support roles. Regarding cases A, B, E and F the informal assessment clearly reflects the formal project leadership roles. In cases B and D members of the central support team hold equally significant informal positions, whereby the later setting consists of three separate projects. Interestingly, the majority of corresponding informal leadership positions in case D were held by project sponsors and not designated members of the core team (see appendix K for details). Even clearer, the general informal assessment focusing on case C does not concur with the formal tripartite team structure as depicted in Table 6-16.

Table 6-16: Comparison of informal assessment and formal team roles regarding team-based sharing processes

		Case A		Case B		Case C		Case D		Case E		Case F	
Informal assessment		Actor	Formal	Actor	Formal	Actor	Formal	Actor	Formal	Actor	Formal	Actor	Formal
Prestige	+	A33	Member	B15	Leader	C10	Member	D25	Support	E12	Leader	F10	Leader
		A11	Leader	B19	Support	C15	Leader	D18	Leader	E11	Member	F13	Member
		A37	Member	B20	Support	C11	Member	D24*	Member	E13	Member	F12	Member
		A20	Member	B18	Support	C13	Member	D19*	Leader	E17	Member	F20	Member
	-	A13	Member	B16	Member	-	-	D10	Leader	-	-	F11	Leader
Activity	+	A11	Leader	B15	Leader	C10*	Member	D25	Support	E12	Leader	F10	Leader
		A33	Member	B18	Support	C11*	Member	D18	Leader	E11	Member	F13	Member
		A17	Member	B19	Support	C15	Leader	D24	Member	E13	Member	F12	Member
		A13	Member	B20	Support	C13	Member	D19*	Leader	E17	Member	F20	Member
	-	A18	Member	B16	Member	C12	Member	D10*	Leader	-	-	F11	Leader
Influence	+	A11	Leader	B15*	Leader	-	-	D22*	Leader	E12*	Leader	-	-
		A33	Member	B18*	Support	-	-	D24*	Member	E11*	Member	-	-
		A20	Member	B19*	Support	-	-	D25*	Support	E13*	Member	-	-
		A13	Member	B16*	Member	-	-	D15	Member	E17*	Member	-	-
	-	A22	Member	-	-	-	-	D19	Leader	E14	Member	-	-

* Indicates equal values

Source: Developed for this research

Other helpful descriptors of boundary-crossing information and knowledge sharing activities are specific team member-related brokerage roles. Table 6-17 compares the case-related types and quantities of agent positions, while simultaneously indicating team size and number of work locations. Although, quite naturally, team size seems to be one important prerequisite for the existence of appropriate functions (see cases A and D), it is not the only precondition as the comparison of cases B and F shows. Although both settings posses equal descriptive characteristics, case B shows a balanced spectrum of brokerage roles, whereas regarding case F two members hold strong liaison positions. The last two project settings reveal no (case C) or one very weak brokerage activity (case E).

Table 6-17: Quantity and type of case-related brokerage roles

	Case A	Case B	Case C	Case D	Case E	Case F
Team size / No. locations	26 / 3	11 / 4	9 / 4	16 / 11	9 / 7	14 / 3
Coordinator	1x	-	-	-	-	-
Consultant	2x	1x	-	2x	-	-
Gatekeeper	1x	1x	-	1x	-	-
Representative	1x	1x	-	1x	-	-
Liaison	3x	1x	-	3x	1x	2x

Source: Developed for this research

Next, patterns and schemes emerging from the cross-case evaluation of additional variable–related characteristics will be introduced and discussed.

Additional variable-related characteristics

The subsequent description of findings is primarily based on results documented in appendices P (Numeric format) and Q (Graphical format) of this dissertation. The examination of *Sub-Group Strength* shows a generally stable pattern within a value range from 4,0 and 6,0, but with two exceptions. Case A results fluctuate between 10,0 and 12,4, whereas case D reveals a varying progression between 6,0 and 9,0 with two local maxima for variables ‘Knowing’ and ‘Access’. Focusing on *Network Density*, three groups could be identified. Case A results are quite stable around a value of 1,0. Cases B, D and E show an increasing course ranging from 1,8 up to values between 2,5 (D) and 3,5 (B). And finally cases C and F, which both stay at a comparatively high level of around 4,0. In addition, nearly all cases show local maxima for variable ‘Cost’. Regarding *Network Cohesion* five out of six cases reveal an generally increasing course with two minima for variables ‘GetInfo’ and ‘Access’ and a maximum for

'Knowing'. Only case C reveals a fluctuating pattern around a comparatively low value of 0,6.

Interestingly, the progression of *Actor Simple Prestige* mean nearly perfectly copies the case-related network density results patterns described above, although at a lower numeric level. Referring to the corresponding standard deviation cases C and D show a very varying progression compared to the other four cases. Referring to *Actor Degree Centrality* mean all cases exhibit very stable patterns across variables ranging from 0,45 for case A up to 0,95 for case C. Focusing on standard deviation, case C shows quite fluctuating and non-directional results. Very heterogeneous courses could be identified regarding *Actor Betweenness Centrality*, with cases A and F at the lower end (0,00) and cases D and E at the higher end (0,06) of the results spectrum. In concordance with earlier findings a highly irregular pattern for attribute-related mean as well as standard deviation could be found focusing on case C. Targeting the last investigated characteristic, *E-I Index*, mean and standard deviation result patterns reveal opposite pictures, thus cases with a low mean, e.g. case F, show a high deviation, whereas cases characterised by high average values, e.g. case A and E, display low deviation results. The subsequent part elaborates issues and relationships derived from a cross-variable correlation perspective focusing on project-related sharing processes.

Cross-variable relationships

The examination of cross-variable structural equivalence focusing on project-related sharing processes (see Table 6-18 for details) reveals a pairing of variables 'Knowing' and 'Value', thus in all cases theses two variables show equivalent results. Moreover from a cross-case point of view, the variable 'Access' in general showed the highest correlation with the sharing matrix, whereas control variables 'Gender' and 'Tenure' expose no structural equivalence. Focusing on control variables 'Proximity' and 'Sub-group', the significance level is positively liked, thus either both of them show relevant correlation with team-based sharing activities or none of them (see cases A, B and E in Table 6-18). It should be mentioned that exactly these three cases poses a recognisable and balanced spectrum of brokerage roles (see Table 6-17). In congruence with earlier SNA findings, case C reveals an abnormal behaviour referring described general patterns and notions; an aspect, which will be investigated further during the next section of this dissertation.

Table 6-18: Assessment of cross-variable structural equivalence focusing on project-related sharing processes derived from SNA correlation analysis [17]

	Case A	Case B	Case C	Case D	Case E	Case F
Knowing	0,656 ***	0,599 ***	0,545 **	0,811 ***	0,627 ***	0,651 ***
Value	0,654 ***	0,599 ***	0,581 ***	0,814 ***	0,649 ***	0,647 ***
Access	0,712 ***	0,686 ***	0,699 ***	0,792 ***	0,701 ***	0,725 ***
Cost	0,654 ***	0,686 ***	-	0,755 ***	0,591 ***	0,637 ***
Gender *	-	-	-	-	-	-
Tenure *	-	-	0,109 **	-	-	-
Proximity *	0,296 **	0,591 ***	-	-	0,418 **	-
Sub-Group *	0,225 ***	0,756 **	0,702 **	-	0,591 ***	-

* Control variables
** $p < 0,05$
*** $p < 0,001$

Source: Developed for this research

In summary, the first analytic step focusing on quantitative SNA results included a case-by-case analysis following a predefined three-stage procedural sequence. During the first stage, the case-specific information and knowledge sharing networks have been visualised and significant team member characteristics and positions e.g. central and peripheral graph positions or brokerage roles been analysed. Primary measures and techniques utilised were SNA graphs developed using IKNOW (2003) as well as NETDRAW (2004), hierarchical clustering (Borgatti, Everett & Freeman 2002) to support the identification of subgroups and a brokerage procedure proposed by Gould and Fernandez (1989) to uncover specific agent functions like gatekeeper, coordinator or liaison.

The second stage focused on the examination of additional variable-related characteristics. An important aspect was member-level evaluations focusing on knowledge awareness, knowledge relevance and cost of bilateral sharing. Main calculations and techniques applied were actor indices Actor Simple Prestige, Actor Degree Centrality and Actor Betweenness Centrality computed using IKNOW (2003). These three measures have also been used in the first stage to investigate case-related information and knowledge sharing networks. Further, UCINET (2004) has been employed to identify and analyse sub-group strength and structure, compute network density and cohesion indices and, finally, to calculate the E-I Index, hence the balance of internal vs. external [communication/sharing] relationships.

[17] Based on Pearson correlation index calculated using UCINET (2004)

The third and last stage focused on cross-variable relationships and tested the association between independent (‘Knowing’, ‘Access’, ‘Value’ and ‘Cost’) and control (‘Gender’, ‘Tenure’, ‘Proximity’ and ‘Sub-Group’) SNA variables or better networks, and project-related information and knowledge sharing activities. QAP-Correlation analysis (included in UCINET 2004) has been utilised to determine relevant Pearson correlations and Jaccard coefficients including their significance as well as other descriptive statistical measures.

In a second step, a more holistic cross-case and cross-attributes pattern analysis has been carried out to reveal possible relationships and/or common themes. First, a comparison targeting the informal assessment of participants’ prestige, activity and influence and their generic formal team functions, thus leadership, member and support roles has been carried out. Then, case-related types and quantities of brokerage positions, under consideration of team size and number of work locations, has been contrasted and discussed. Further, the seven main descriptive attributes e.g. Actor indices, network density or E-I index, have been organised and systematically investigated to reveal general, thus case-independent, relationships and concepts. Finally, cross-variable structural equivalence (based on correlation results) focusing on project-related sharing networks has been assessed and general patterns and themes identified.

The next chapter represents the final stage of the data analysis process merging qualitative and quantitative research findings, thus providing the necessary information-rich and multi-faceted knowledge repository targeting the further clarification of the research issues as well as focusing on the higher-level research question.

7 Conclusions and Implications

7.1 Introduction

"When it comes to knowledge management, culture trumps all other factors."
[Larry Prusak]

The preceding chapters 5 and 6 elaborated on the results of qualitative interviews and quantitative data sources (Social Network Analysis) in detail. The essential objective of this final chapter is to show the distinct contributions and implications of this research for the related body of knowledge. In a first preparatory step, the general line of argumentation, hence key developmental aspects of this dissertation, will be summarised. Then, a cross-method synthesis will support the identification of obvious patterns and tentative relationships combining relevant findings from the two analysis chapters around the five research issues as well describing significant case-related results. Next, these findings for each research issue as well as the research question itself will be discussed within the context of prior research examined during the literature review. This part will clearly distinguish between advances on previous research and important contributions or additions. Advances are of interest because they add a new depth to our understanding of knowledge management in virtual project environments. In contrast, contributions reveal confirmation or disconfirmations of established concepts or new areas which have not been raised in previous literature. The next section addresses implications for theory, practice and methodology as well as limitations that became apparent during the process of the research. The last section exhibits suggestions targeting the selection and design of further research.

The development of the *research problem* for this dissertation was stimulated by the ongoing growth of inter-organisational alliances and much larger matrices of interactive network organisations. In this context, projects represent one of the most common 'vehicles' for inter-organisational activities and it will become increasingly important for these organisations to take steps to capture and build on the learning that takes place during a project. However, there is limited empirical research from a knowledge perspective of managing multi-location project teams whose work is highly complex in nature and a membership mix of internally employed personnel as well as external partners. With knowledge as the new strategic resource, it might be of great strategic interest for firms or organisations to identify and manage those factors in virtual project teams supporting knowledge creation and transfer leading to sustained advantage as well as controlling possible “knowledge leaks” weakening their position in the long run. This discovery finally led to the specific formulation of the following *research question*:

RQ: How do socio-cultural enabling conditions and network-related factors influence knowledge creation and exchange in virtual project teams?

A comprehensive literature review revealed a wide and interconnected field of disciplines with a recognisable focus on socio-cultural conditions as well as network-related factors and processes. The overriding insight, emerging from the literature investigation, is a prevalence of inflexible, bureaucratic and thus often inappropriate management models and corresponding organisational standards and cultures. This increases the danger of chronic self-deception in the formal organisation, partly reinforced by the camouflage behaviour of individuals in conforming to the pseudo-rational models. Despite the existence of many theoretical [knowledge management] models and approaches, no clear evidence could be found regarding their practical utilisation in dynamic and complex real world scenarios like virtual project environments. Several - often interrelated - key issues emerged from the review, which formed the basis for the development of a theoretical framework and the final formulation of research issues. Based on the inherent complexity and heterogeneity of the investigated phenomenon, convergent interviewing was used to discover further ideas and dimensions of the research problem. The analysis and interpretation of the interview findings, in combination with the previous literature research, allowed the refinement of the preliminary research question and derivation of the following five *research issues*:

RI 1: How do the level and type of *trust* within a virtual project team affect the creation and exchange of knowledge?

RI 2: How can a *shared language and a common vocabulary* impact knowledge management in virtual project teams?

RI 3: To what extent do *informal networks* influence the knowledge creation and exchange in virtual project teams?

RI 4: How do *boundaries* support or hinder knowledge creation and exchange?

RI 5: What are the *risks* associated with limited awareness regarding the quality of the existing knowledge repository and uncontrolled knowledge diffusion processes in virtual environments?

7.2 Cross-method synthesis

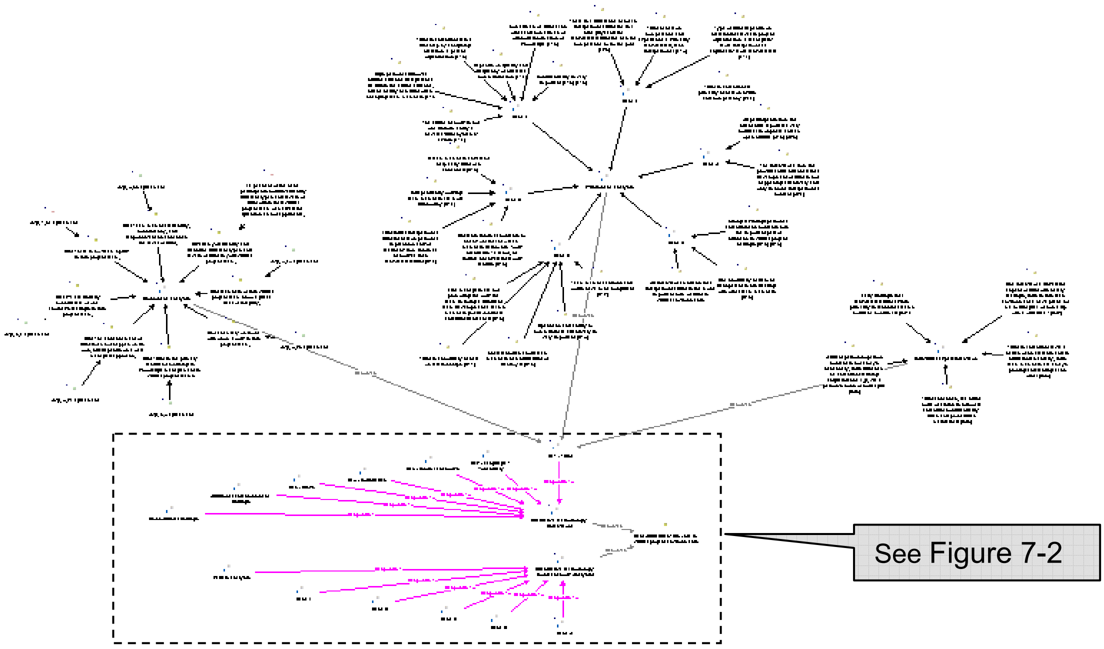
Based on the developed multi-method research approach around 137 qualitative findings primarily derived from the implementation of depth-interviews and 154 quantitative findings gained from the conducted Social Network Analysis (SNA) could be identified. The quality of the synthesis of both sources is restricted by the effectiveness with which one can handle the inherent complexity, which is both broad and deep. Socio-cultural aspects in knowledge management, like many other areas of human study, require both incredible attention to minutiae and a comprehensive view of many broad domains simultaneously. One important limiting factor that sets the upper limit of a researcher's combinatory capability is that there is too much information and that it is too complex to be able to process. Therefore several tools have been evaluated during the analysis phase of this research to assess their potential usefulness.

After consultations with researchers from the University of Southern California (USA) as well as from the Knowledge Media Institute at the Open University (England), the software tool Compendium (2005) has been chosen to support this final analytic phase. Originally developed for collaborative modelling, organisational memory and meeting facilitation this software offers the functionality to develop a discourse/argumentation ontology [18], which makes possible innovative services for navigating, visualising and analysing the composed network of findings. The software uses the IBIS notation (Issue-Based Information System) developed by Rittel (1972), a methodology which offers the functionality to visually map key issues, possible responses to these, and relevant arguments. Compendium (2005) builds on a hypermedia database, thus generated maps (see Figure 7-1) are not 'flat' drawings, but views onto a relational database which can be rendered in multiple formats. A given node (e.g. representing a

[18] A (shared) expression of belief, an agreement on the terminology (and sometimes the meaning) for communication and action. Ontologies serve to bound discourse, facilitate communication within & across communities and networks, leverage action by gathering agreement around values, objects, the way things are and what is 'out there' that is important. Ontologies have a large influence on identity and help with the tacit transfer of context (see http://www.semanticweb.org/knowmarkup.html)

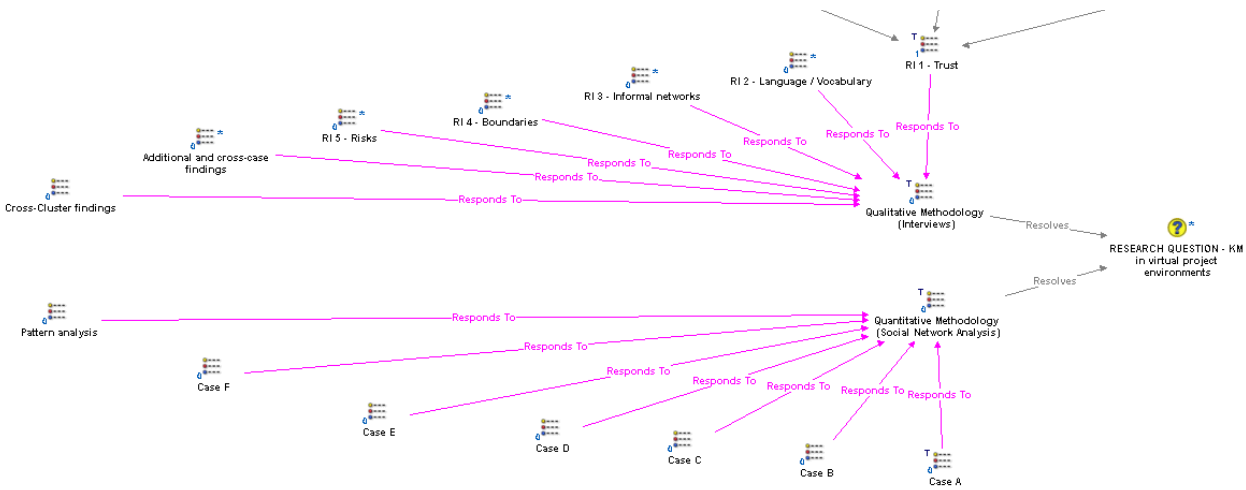
concept from literature review, a research finding or interpretive argument) can appear and be updated in multiple views, and be assigned user-defined semantic tags, providing a flexible medium for managing connections between nodes across different contexts.

Figure 7-1: Hypermedia-based argumentation ontology - Example map visualising relevant results and findings targeting research issue 1 'Trust'



Source: Developed using Compendium (2005)

Figure 7-2: Hypermedia-based argumentation ontology - Enlarged area of example map



Source: Developed using Compendium (2005)

The overall process started with the implementation of the general analytical framework as depicted in Figure 7-2 and the subsequent integration of relevant results and findings. The third step targeted the categorised linking of nodes, followed by the allocation of descriptive tags, two aspects which in turn simplified the reduction of complexity and eased the identification of cross-method relationships. To comply with the chosen research methodology and to enhance the overall readability the following presentation of synthesised findings follows an [research] issue-by-issue sequence and ends with a discussion of key findings targeting information and knowledge sharing. Next, cross-method results regarding the first research issue 'Trust' will be explained.

Research Issue 1 – Trust

The majority of participants rated their project environment as trustworthy, but urged the need for a systematic management approach targeting the enhancement of trust. Moreover reliability, consistency and responsiveness were highlighted as influential promoters of trustful work environments. Team members belonging to case A stated that stakeholders from client and provider side perceived the quality and development of trust differently. 'External' actors seemed to have problems establishing the necessary trustful relationship with members of the client team(s) (see Table 5-8). This qualitative finding was supported by quantitative results computed from summary questions, where client and provider participants show contrary outcomes targeting team member integrity, reliability and team spirit. Nevertheless, SNA results showed that, from an information and knowledge sharing point of view, the most prestigious and influential team members belonged to the [external] consulting firm. This result concurs with comparatively high sub-group strengths of all indirect SNA variables, an aspect which might indicate boundaries of separate belief and trust systems (see Table 6-3 for details). In addition and focusing on the SNA control variables, only 'Proximity' and 'Sub-Group' revealed significant correlations, thus in contrast to the aspects of 'Gender' and 'Tenure', both variables moderate sharing activities in this particular project environment to a certain degree. All interviewees from case B stressed that interpersonal trust is the most important form of trust in virtual environments. Respondents highlighted the relevance of existing strong relationships as well as behavioural transparency and consistency as important prerequisites for successful virtual work. Given the fact that interpersonal trust takes time to develop, the visualisation of team-based communication behaviour showed that many long term members work in remote areas with only irregular face-to-face contact compared to much newer members of the central coordination team (see sub-section 6.2.2 for details). Nevertheless, SNA results indicated that, referring to information and knowledge exchange, the most prestigious and active team members could be found in this particular coordination team.

Results originating from case C showed that openness and the ability to communicate effectively was very important in this virtual team. Despite the fact that two offsite kick-off meetings were facilitated by a psychologist, some interviewees reported the existence of 'trust system' based on sub-team membership. Given the age of the team and the distribution of its members, qualitative findings further suggested that this trust was primarily based on existing relationships. Both aspects could be supported by a high correlation of SNA control variables 'Tenure' and 'Sub-Group' (see Table 6-7) with team-based communication activities. In this particular setting, trust was reduced by the fact that line managers were not promoting the team's work, thus members got de-focused and team development suffered. Results from case D highlighted different behaviours focusing on the development of trust. On one hand, interview findings suggested that trust increased when team members asked for help, thus social links were established and strengthened. On the other hand, some respondents said that they personally perceive independently working team members as more trustworthy - an aspect, which points in the direction of more task related trust. None of the investigated SNA control variables showed a significant correlation with team-based sharing activities. Referring to the overall picture drawn from a broad spectrum of results this case represents a challenging business environment where team members with professional skills and attitudes might get the necessary portion of initial trust (see sub-section 6.2.4).

Participants from case E reported a high team member fluctuation and stressed that trust in an early project phase derived primarily from organisational membership. They additionally emphasised that project partners deliberately withheld information or knowledge. SNA results supported the notion that the project team is separated into one Germany-oriented group, a more international focused group and two single individuals. A high statistical correlation between communication activities and member proximity / group membership supports the mentioned qualitative findings (see Table 6-13). One individual expert stressed that a direct person-to-person contact is not always necessary, thus trust can be established using acquaintance e.g. via a person's boss or colleague (see section 5.4.1). One possible approach to investigate this aspect further is the calculation of brokerage roles, preferably 'Liaison', which was the most prominent one in all investigated cases. Qualitative results from case F highlighted the difference between interpersonal trust, thus “he is a nice guy”, and the task-related trust e.g. “he has the competence to do the job”. Further interviewee feedback linked the type of trust with the hierarchical level in the project organisation, thus interpersonal trust is attributed to managers; whereas the task-related trust is more connected with operational staff e.g. specialists or engineers. Like case D, the investigation of SNA control variables in this virtual project team showed no significant correlation with team-based sharing activities. Despite individual comments, more than 70 per cent of the interviewees couldn’t’ identify different types and levels of trust within their virtual project team or marked the question as not applicable (see Table 5-9). Trust is established via a series of small tests and is build incrementally, thus team members are always probing and testing each other. Findings suggest that trust can be enhanced, if a strict code of ethics is followed and confidentiality rules and procedures maintained. The next section presents cross-method findings focusing on the research issue ‘Language and vocabulary’.

Research Issue 2 – Language and vocabulary

Two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language. Focusing on knowledge sharing and utilisation 42 per cent of the interviewees reported negative experiences or problems in this area and simultaneously highlighted the importance of open and honest communication as a necessary prerequisite. Different knowledge levels, a lack of language homogeneity and the absence of transparency in a highly dynamic project environment could be identified in case A. A potential indicator for this effect might be a comparison of the SNA variables of ‘Contact’ and ‘Knowing’, because given the right circumstances a frequent contact should lead to better understanding of a persons’ cultural belief system and knowledge repository. A significant correlation of the two variables could not be observed in this particular case setting. Referring to case B, participants emphasised that communication problems in multicultural and interdisciplinary project environments are common and need to be addressed in a consistent and fast manner. None of the interviewees reported problems with knowledge sharing / usage; a fact which might be attributed to the autonomous position [and work] of key team members as shown in the SNA graphs (see Figure 6-7 and Figure 6-8).

Team members of case C received initial training regarding the particular project contents, which in turn supported the alignment of project language and vocabulary. Nevertheless interviewees noted the context dependence of knowledge and mentioned consecutive problems when applying codified (explicit) knowledge in new project situations. Aspects related to case D supported earlier findings targeting language proficiency. In this setting an English native speaker gained a leadership position within the team, partly because of his ability to express his ideas and concepts more eloquently. Further, interviewees named different perceptions and interpretations of concepts, items or words as another obstacle and highlighted the need for context analysis capabilities (language, culture, vocabulary) as important prerequisite for effective project communication. One participant belonging to case E stressed that it took him around four months to get used to the specific project language and vocabulary. Results from SNA showed that from an information and knowledge sharing point of view this individual is still somewhat 'isolated' (see Table 6-13). Additional findings suggest that especially in multicultural project settings a broader description, explanation and discussion of used concepts, issues and words is necessary to avoid misinterpretations and subsequent tensions or conflicts. Regarding case F evidence from the interviews implied that new team members rated the project-related communication as primarily formal and experienced problems regarding knowledge sharing. The underlying adaptive processes could be demonstrated using SNA findings where the knowledge perception ("Mental knowledge map") focusing on one of the 'new joiners' (2 months) was quite vague, whereas another new team member (8 months) was rated very high (see sub-section 6.2.6).

The subjective feeling issued by one expert that foreign participants tend to be shy and somehow reserved referring their communication behaviour couldn't be validated by corresponding SNA findings. For example, regarding case E results couldn't identify one homogeneous Asian sub-group as mentioned by one [Asian] participant (see sub-section 6.2.5) and focusing on case F Asian team members showed more outgoing communication links than their European colleagues. One expert wisely said that words and numbers are often not the connecting instrument, but the separating one and that maps (or sketches as another interviewee mentioned) have the potential to provide a common basis. From an efficiency and financial point of view, it has to be remembered that knowledge, either tacit or explicit, has to be 'translated' to fit into the local context before it can be successfully utilised in a given project environment. Further, it came apparent that synchronous communication activities like meetings, telephone conferences or even online chats put additional pressure on (foreign) participants because of existing (poor) language skills and 'invisible' cultural norms. One of the baseline problems in this context is the fact that SNA methodology can not sufficiently assess the intrinsic quality of communication activities. Hence, the qualitative finding that two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language could not be cross-checked. The subsequent section highlights relevant findings attributed to the research issue 'Informal Networks'.

Research Issue 3 – Informal Networks

Results showed that 75 per cent of the interviewees claimed that they were able to identify informal structures within the project team. The investigation of case A revealed substantial differences within the project team regarding the judgement of informal networks. Participants from the three client sub-teams characterised informal structures with comments like "could be very dangerous", "knowledge is power mentality" and "the project may suffer", whereas interviewees from the provider side had a more positive attitude or as one team member said "things progress faster and easier". Informal groups or networks represent a safe and secure environment, for example results from case B highlighted that informal structures represent useful forums to discuss one's thoughts and ideas before presenting them to the whole team (see section 5.4.3). All interviewees belonging to case C rated informal networks as very important and urged that without this "informal" knowledge the team could not do what it is intended to do. One participant added that informal networks can be highly beneficial to overcome silos.

Qualitative findings originating from case E stressed that informal project 'cliques' tend to have a relative high degree of internal communication and therefore, from a time and energy point of view, the project may suffer. Although the E-I Index, thus the external-internal communication ratio (see appendix N for details), couldn't be calculated for this particular project, activities of informal structures should be aligned with the overall project goals or as one interviewee said "A project needs a formal backbone and informal 'fuel' for its successful implementation". In this context, the majority of participants rated formal project processes and aspects as the primary driving force within their project environment and not informal groups or networks. The SNA-based comparison of formal project roles and informal performance assessment; hence team members' prestige, activity and influence (see Table 6-16) partly supported this qualitative finding. Four out of six analysed cases showed a great conformity between the formal and the informal structure, whereas two projects (case C and D) showed significant differences.

One potential drawback of informal structures is a loss of transparency and knowledge sharing efficiency, because although they can be effective and safe knowledge markets, the rest of the formal project team will not necessarily profit from this gain. Thus in essence, informal “power” is nothing without (adequate) formal control. Therefore some participants suggested to formalise (relevant) informal groups or networks to let them contribute ‘openly’ to project implementation and success, particularly because evidence could be found supporting the notion that shared information and knowledge within an informal context has a higher quality and relevance compared to its formal counterpart. Nevertheless, the statistical analysis of case interviews revealed that, in contrast to individual interviewee statements, informal contacts were valued only slightly more suitable for knowledge sharing than formal ones. From an external perspective, informal networks can be viewed as bridges connecting the project with the organisational surroundings, thus allowing necessary adjustments and modifications as the organisational environment changes. Next, cross-method aspects referring research issue 4 ‘Boundaries’ will be elaborated.

Research Issue 4 – Boundaries

The connection between geographic boundaries and the development of trust was highlighted by the fact that the majority of interviewees denied (see Table 5-15) that trust can be build 100 per cent virtually. Further, it became clear that knowledge can be best shared in close personal contact with other team members and that regarding (technical or personal) complex issues team members definitely preferred a direct face-to-face communication instead of a virtual one. Based on SNA results 50 per cent of the case studies revealed a significant correlation between the aspect of proximity and information / knowledge sharing activities. Participant feedback supported the notion that projects would run smoother (and better project results could be realised) if more face-to-face interaction would be possible. Two out of three interviewees from case A mentioned the existence of structural and geographic boundaries representing an obstacle for knowledge sharing activities targeting the different formal groups involved (see section 5.4.4). These findings coincide with the fact that the face-to-face contact frequency regarding provider and client team members differs significantly (29 days vs. one day). However, the investigation of the group-related communication behaviour using SNA revealed a stable pattern, hence the existing five formal sub-units (see Table 5-2) tend to have increased outward information and knowledge sharing relationships indicating cross-unit collaboration (see Figure 6-3). This assessment was supported by a broad spectrum of brokerage roles as depicted in Table 6-1. Given the deviation between individual, subjective participant statements and the quantitative, statistical character of SNA results, the importance of a holistic analytic framework including collective feedback sessions becomes evident.

Findings originating from case B showed that a sole fixation on explicit knowledge transfer, because of geographical constraints, in combination with a lack of joint learning possibilities has negative influence on boundary-spanning knowledge sharing activities. These knowledge management approaches tend to slip more and more into the area of mere information management, because important contextual aspects fade away during the codification, storing and recombination processes. Findings related to case C supported this idea, because interviewees highlighted the relevance of personal proximity focusing on the 'correct' reassembly and arrangement of shared project knowledge. In addition, the analysis disclosed that different appraisal systems drive people in different 'silos', fostering mistrust and increased jealousy. Case D revealed the relevance of F2F meetings as an important environment for conscious and unconscious evaluation and subsequent development of interpersonal trust or distrust. Interview feedback uncovered the fact that the frequency of F2F contact concurred with the individual project phase and situation (Up to four days a week in early stages or crisis situations and later two days on average). The SNA interpretive process showed that individual results e.g. visualisations of communication behaviour, should not be assessed in isolation, but always under consideration of supplemental evidence like brokerage measures or network indices. Otherwise the risk of misinterpretations based on preconceived notions, individual bias or inappropriate contextual understanding is comparably high.

Cultural boundaries were an issue in another case setting (case E), where Asian members of an airline alliance formed some sort of informal sub-group based on similar strategies, English language skills and cultural background (see Table 5-14). Additional structural boundaries based on length of membership and airline size were mentioned by another interviewee, resulting in several degrees of integration. SNA results (see sub-section 6.2.5) proved the peripheral position of several Asian team members. Evidence from case F highlighted the necessity of clear demarcation of responsibilities to ensure the control of unique knowledge within virtual project environments. The case-related calculation of brokerage roles, especially in case A and D, provided a systematic means for the identification of important ‘connectors’ focusing on the activation of valuable knowledge repositories (see Table 6-17). The analysis process proved that brokerage roles as well as a comparison of informal vs. formal team functions (see Table 6-16) could deliver helpful insights building the foundation for necessary interventions e.g. changes in team structures or the adaptation of communication processes.

In summary, several types of boundaries could be identified. Geographic boundaries fostered the reluctance of individuals to contact other knowledgeable, but not collocated team members. Moreover, this sort of constraint hinders the necessary context building in such a way that the ‘correct’ reassembly and arrangement of shared knowledge is disturbed. Cultural boundaries were evident in one case where Asian members formed some sort of informal sub-group based on similar strategies, English language skills and cultural background. Structural boundaries based on membership tenure and company power / influence could be identified in another setting, resulting in several degrees of integration. This finding concurs with evidence that organisation-related grouping or conglomerating of project staff represents an obstacle for effective knowledge sharing activities. The majority of interviewees highlighted the importance of physical proximity (especially in Asian cultures) regarding the development of interpersonal trust as well as focusing on the solution of complex technical or personal issues. All the mentioned limitations resulted in a sort of ‘fuzziness’, preventing team members from assessing other individual’s tacit knowledge repositories and building project-related mental knowledge maps. It came apparent that there is a clear difference between people who just do their jobs and boundary spanners who can bring in new and on-demand knowledge from other areas, thus strengthening a project’s reactiveness in dynamic and challenging situations. Further interviewee comments stressed the importance of project managers to be socially connective, thus linking small collocated cliques within the surrounding virtual fabric, especially in multicultural and interdisciplinary environments. The following paragraph presents synthesised findings referring the fifth and last research issue ‘Risk’.

Research Issue 5 - Risks

More than two thirds of the interviewees claimed that they were not aware of knowledge losses with respect to their actual project (see Table 5-17); nevertheless the majority also said that knowledge is always lost in project teams. The fact that participants rated collaborative partners as more experienced in certain areas represents one important initiator for project-related knowledge sharing or, in some cases, knowledge theft. The investigation of participant feedback referring case A provided several insights on how knowledge management is actually lived in this multiparty project team. One participant from the provider side revealed that the necessary exchange (codification) of knowledge has not been considered in the project assignment (no clear contractual regulations) and that these activities are therefore viewed as additional, unplanned work. The basic knowledge management approach on the client side was limited to the management instruction to make notes and to ask. The client sub-teams were viewed by provider representatives as too much specialised and characterised by a "Knowledge is Power" mentality, whereas the provider himself complained less of internal personal interaction and no adequate support processes to foster knowledge generation and sharing. SNA showed that although two members from the provider side were rate as most prestigious, influential and active information and knowledge sharers (see Table 6-3), the calculation of brokerage roles revealed that team members belonging to the client side held important gatekeeper and coordinator positions (see Table 6-1).

Given the environmental research background of case B insecure property rights and misguiding governmental regulations have been perceived by participants as potential risks regarding knowledge transfer (Keyword: Ethical responsibility). Further, it has to be insured that the technical and scientific integrity of codified knowledge 'survives' the translation process in global work settings. SNA identified one key player from the central coordination team (see Table 6-6), thus this team member not only held a strong gatekeeper and representative position, but also showed high prestige, influence and activity regarding information and knowledge sharing activities. The analysis of case C showed that the teams corporate surrounding was characterised by a static employee structure (80 per cent of the employees are working for the company for more than 10 years) with a resistance to organisational change (see Table 5-16). Internal calculations revealed that the financial risk of losing the companies intellectual capital through retirement equals a sum of 300 Million US$ within the next five years. Qualitative findings showed a “survival mentality” of team members, because of the ongoing organisational changes; an issue, which fostered knowledge hoarding. In this context, SNA results (see Table 6-8) indicated that members of the dominant cultural change team had a balanced information and knowledge sharing behaviour (see sub-section 6.2.3) and a clustering analysis (see Figure 6-9) identified cross-team and cross-location sharing relationships. In contrast, no brokerage positions e.g. gatekeeper could be identified and sub-team membership had a significant influence on project-based sharing activities, two aspects which support the qualitative findings. Qualitative findings originating from case D highlighted a "Knowledge is power" mentality and a strong competition within the organisation. The E-I index (see appendix N), thus the assessment of internal versus external communication links, revealed that members belonging to project T had a higher degree of inward communication, whereas project B and the central coordination team (control group) showed a significant external focus (see Figure 6-10). SNA further disclosed two strong consultant roles for members of project T as well as a gatekeeper and representative position for one individual belonging to project E (see Table 6-9). The later one also showed high levels of prestige, influence and activity focusing on cross-project information and knowledge exchange.

Case E revealed the notion that several Asian team members are not very proactive in expressing their opinion in public or sharing their project-related knowledge / experience. One identified risk in this particular project environment was the discovery that internal organisational guidelines of involved project partners sometimes overrule project issues and thus influence the realisation of project targets negatively. Most project partners held joint internal briefings before important conference calls or meetings to discuss their strategic position and to decide what knowledge or information to share and what not to share. Focusing on case F contractual regulations with clients not only covered product issues, but also the provision of technological know-how to operate these complex systems. From an internal point of view however, some sort of defensive behaviour of different corporate divisions could be identified, which hindered not only necessary knowledge sharing activities, but restricted reactivity in project-related crisis situations. SNA disclosed that individuals with a shorter team membership have between 25 and 70 per cent fewer communication links compared to older project members. Interestingly, the only existing two brokerage roles could be attributed to team members located at company headquarters, thus these brokers supported (or even enabled) the boundary-spanning connection of team members.

In the context of 'knowledge loss', SNA findings highlighted the significance of the aspects of 'Knowing' and 'Value' targeting team-based sharing activities. Thus, it is questionable whether team members posses a reliable mental map of available project-related explicit and tacit knowledge sources or in other words: How could one realise a loss of something he was not aware of? Further, as case-related evidence proved a growing tendency to trade important technological know-how, a regular strategic evaluation and categorisation of important knowledge resources is necessary to protect a company's key knowledge assets. Additional findings revealed that reflective learning is not valued adequately, thus knowledge is lost, because of a primary focus on immediate (task or project-related) problem solving, but neglecting its organisational and long term relevance as 'fuel' for organisational learning processes. One interviewee stressed that too much time is spend on documenting and less time is spend on actually 'capitalising' existing knowledge. After having discussed the five research issues the subsequent paragraph elaborates cross-method phenomenon targeting the key aspect of the research question, thus [information and] knowledge sharing processes. First, case-related findings will be discussed, and then the focus will shift to more general issues and concepts.

Information and knowledge sharing

Referring to ***case A***, a joint national development and implementation team, the most active drivers targeting information and knowledge exchange were team members (A33 and A11) belonging to the IT consulting firm, whereby the later one represented the formal project manager. SNA results supported interviewee statements that the strongest relationships and prominent sharing activities were visibly concentrated in one particular project location. Despite a broad spectrum of brokerage roles, acting as a potential basis for systematic sharing activities (see Table 6-1), all debriefed participants reported problems with project-related knowledge sharing. Although two out of three interviewees highlighted lacking physical proximity as one major problem, the SNA-related correlation analysis revealed only a weak linkage index value (see Table 6-2) compared to other case settings. On a detailed team member level knowledge awareness regarding certain individuals (A16, A21, A35, A14, A15) was quite vague and the knowledge of other actors (A25, A17, A33) had a great relevance for the majority of the team. Accessibility of particular team members (A21, A16, A35, A14) was limited and sharing of information and knowledge with specific individuals (A17, A25, A19, A23) was perceived as comparatively costly. Quantitative and qualitative findings suggest that team members exchange necessary knowledge on a 'on call' basis, primarily relying on their personal formal (organisational) as well informal network and to a lesser extent using the formal project organisation.

One participant from ***case B***, a global multicultural environmental research and development consortium, stressed that a sole fixation on explicit knowledge transfer, because of geographical constraints, in combination with a lack of joint learning possibilities has a negative influence on boundary-spanning knowledge sharing activities. Results showed that the majority of experienced individuals with a long term team membership held peripheral positions, from a geographical as well knowledge sharing point of view. Central positions and strong sharing relationships can be attributed to individuals belonging to the global coordination team located at the consortium's headquarters (see Table 6-6), a finding which is supported by high correlation values regarding sub-group membership and related information and knowledge sharing activities (see Table 6-5). In this context, interviewees urged that the way of looking for new knowledge within the consortium's framework changed in the last four years and that the global unit plays a key role in the synthesis of new knowledge. Interestingly, results disclose that team member B18, belonging to the coordination team, has only external sharing relationships, but none with her two colleagues (see sub-section 6.2.2). A fact, which might result from her specific administrative role. On a more detailed level, SNA results proved that the majority of the team had only a vague understanding regarding the knowledge repository of actor B12 and that the knowledge of other individuals (B15, B20) was highly valued. In addition, the accessibility of several team members (B10, B12, B13, B14) was insufficient and communication with certain actors (B18, B15, B16) was rated as least costly (see Table 6-6). Additional evidence could be incorporated based on consultation activities structured following an analytical framework on "harnessing science and technology for sustainability" developed by Harvard University researchers as described in Tomich (2004). Results showed that 92 per cent of the 42 participating consortium' researchers felt that additional methods and procedures have to be developed to integrate different types of knowledge (scientific, local, policy). Around 80 per cent highlighted the existence of important social, cultural and political barriers hindering the desired knowledge interaction. Although the consortium revealed an increased awareness targeting soft aspects like barriers, communities, mediation and perceived itself as a 'learning organisms', a guiding knowledge sharing and integration framework and corresponding institutionalised processes, are not in place yet.

Based on the analysis of qualitative as well as quantitative data ***case C***, one of Australia's leading communication providers, can be characterised as challenging and demanding team environment. The project team, consisting of three individual sub-units, was formed around six months before data collection [and was restructured eight months afterwards]. SNA results showed a high correlation between sub-unit membership and related information and knowledge sharing activities (see Table 6-7) and, in contrast to qualitative interview evidence, SNA findings revealed that physical proximity had no significant influence on project-based information and knowledge sharing. Interviewees valued informal networks as very important for their work, but given the fact that the team building process is actually in its early stages and based on supplemental participant comments, it is questionable whether sufficient informal structures are already in place. Although the calculation of brokerage measures provided no results (see sub-section 6.2.3), hierarchical clustering referring the project-related communication network disclosed two sharing relationships linking team members from different sub-units and locations (see Figure 6-9). On a more detailed level, certain team members (C10, C11, C15) held central positions in nearly all instances, whereas other members (C13, C17) are often situated at the outer boundaries of the sharing network (see Table 6-8). Further, the assessment of one actor's (C14) knowledge capabilities by other team members was quite vague. A phenomenon, which concurs with the isolated physical as well as communication-related position of this particular team member.

Referring to ***case D***, a leading global IT Service company, one interviewee urged, that because of a high team member fluctuation, mentoring and guiding of newcomers to the entry points of the organisational knowledge system, was essential. Qualitative results showed that collaboration tools like software packages or telephones conferences were used on a regular basis in this multi-project setting. SNA findings disclosed a broad spectrum of brokerage roles which might represent the necessary fabric for sharing activities (see Table 6-9). This is a facilitating aspect which might be hindered by departmental power struggles as reported by one case participant. On a detailed level, focusing on the case-related information and knowledge sharing network, some team members' (D11, D14, D16, D23) showed limited accessibility, whereas the assessment of actor's knowledge was quite vague for some others (D12, D16, D22 and especially D26 - see Table 6-11). Further, the knowledge of certain team members (D18, D21, D24) was highly valued. In contrast to over 60 per cent of the investigated cases, the aspects of gender, team tenure, physical proximity as well as sub-group membership had no influence on information and knowledge sharing activities in this multi-project environment (see Table 6-7).

The global airline alliance project investigated in ***case E***, showed characteristics of cooperation as well as competition. Given the different airline business models, project partners deliberately withheld information or knowledge on a case-by-case basis and strategic organisational guidelines sometimes overruled project issues. Nevertheless, as one interviewee said, these barriers must not necessarily have a negative influence on the overall project success. On a detailed level, focusing on team member's knowledge accessibility, two separate sharing clusters (E10, E11, E13) and (E12, E16, E17, E18) could be identified (see Table 6-13). Specific competences and know-how of some team members (E14 and especially E15) are not quite transparent for the rest of the team. Regarding the aspect of 'Value', actor E12 holds a central position; hence his knowledge seems to be very important for other team members. The peripheral position of team member E15 targeting the variable of 'Cost' raises the notion that sharing information or knowledge with this team member is perceived as 'expensive'. In contrast to qualitative evidence derived from case interviews, SNA results couldn't prove one homogeneous Asian sub-group involving particular team members (E14, E15, E17). Calculation of brokerage measures revealed only a weak liaison role (see sub-section 6.2.5).

Focusing on ***case F***, an international project within the engineering and transportation industry, intercultural differences and slightly different sets of behavioural mindsets as well as a strong focus on formal [technical] documentation could be identified. This fact concurs with the coordination and 'buffer' role of the investigated project team between the German Engineering group and its Asian client. Qualitative findings revealed a more or less deliberate protection of interests of involved organisational divisions, resulting in decreased effectiveness of project-related information and knowledge sharing activities. Despite the visually diffuse structure of the team-based sharing network (see Figure 6-18), the implemented hierarchical clustering technique (see Figure 6-19 for details) uncovered three particular exchange relationships between Asian located team members. In addition, the calculation of brokerage roles showed that team member 'F21' as well as 'F23' (both located at company head quarters) hold strong liaison roles (see sub-section 6.2.6). On a team member level, SNA findings disclosed a vague knowledge awareness regarding some individuals (F22, F14, F18, F16, F20) and great relevance of knowledge of several other actors (F10, F12, F13, F18 - see Table 6-15). Accessibility of particular team members (F15, F16, F19, F23) was limited and sharing of information and knowledge with certain individuals (F15, F16, F18, F22) was perceived as comparatively costly.

Regarding ***general issues and concepts*** elaborated during the cross-method synthesis the physical proximity of team members played an important role. The majority of interviewees stressed that knowledge can be best shared in close personal contact with other team members (see section 5.4.4). From a psychological point of view this behaviour is quite natural because humans can use a much broader spectrum of their sensory system to assess and interact with their surrounding, hence they feel more comfortable and secure. Nevertheless, SNA findings supported the notion that it is actually not physical proximity, but an appropriate mental connectedness (see Table 6-18) which enables and supports information and knowledge sharing. Proximity alone does not ensure information about or access to an individual's knowledge repository. Team members have to be able to construct mental knowledge maps or indexes as well as to have timely access to contextual information allowing the appropriate recombination and assimilation of acquired knowledge. Further, more than 95 per cent of the interviewees emphasised that focusing on knowledge management in virtual project settings team members have to possess additional socio-cultural and technical skills to perform effectively (see Table 5-19). A frequency analysis of keywords disclosed that aspects related to "Characteristics / Skills" followed by "People" (see Table 5-18) were mentioned most often by participants. One characteristic of particular importance is an individual's degree of openness which directly affects the build-up of sustainable relationships. In this context, the analysis of SNA variables 'Access' and 'Cost' might represent a good starting point for a team-based investigation of this phenomenon.

Interview summary questions exhibited that the majority of participants rated collaborative partners as more experienced in certain areas (see Table 5-17). This fact is a necessary precondition in multi-disciplinary projects because this complementary expertise is used to achieve a common and clearly defined goal. Problems may arise if overlapping areas of competence exist or if knowledge asymmetries restrict the availability of necessary 'input' for team members to complete specific project tasks. The calculation and analysis of the perceived knowledge value, as part of the utilised SNA methodology, represents an effective device to visualise this aspect and to contrast the result with a knowledge carrier's accessibility for example. Evidence could be found that [the subjective] team-based self awareness / assessment often doesn't reflect reality, thus despite obvious problems no corrective actions have been initiated, until external feedback. This finding is even more surprising as the majority of interviewees claimed that they are familiar with the concept of knowledge management and that their project team has the leadership capability to succeed in knowledge management (see Table 5-19).

It became obvious that it is often the active involvement of a passionate KM champion which stimulates the necessary awareness, creates an atmosphere of urgency and initiates appropriate actions in his area of influence. Especially in big hierarchical organisations KM policies and standards developed at head quarters often don't get sufficiently implemented in foreign countries or project sites. In addition, their content and focus sometimes doesn't reflect the specific local conditions and necessities, hence project members impeach their suitability and non-conformal approaches might flourish. Focusing of SNA findings, it came apparent that in two cases where interview results revealed team inhomogeneities or disturbances, the investigation of informal key actors (see Table 6-16) showed an imbalance between formal and informal roles as well as varying levels of prestige, activity and influence. [19]

Evidence could be found supporting the notion that shared information and knowledge originating from an informal context has a higher quality and relevance compared to its formal counterpart. There is a difference between people who just focus on their formal project role and boundary spanners who can bring in new and on-demand knowledge from other formal or informal sources, thus strengthening a project's responsiveness in dynamic and challenging situations. The calculation of brokerage positions (see Table 6-17) in combination with the investigation of a broad spectrum of SNA graphs e.g. targeting knowledge awareness and accessibility proved to be quite helpful regarding the identification of these gatekeepers or knowledge brokers. This approach also showed to be effective targeting the examination of a project manager's social connectivity, thus his ability to link small collocated cliques within the surrounding multicultural and interdisciplinary project environment.

[19] The project team representing case C was established three months before the data collection and was re-organised several months after the investigation took place. Case D showed a 'knowledge is power' mentality spurred by cross-departemental power struggles.

Table 7-1: General issues and concepts – Key findings

• Not necessarily physical proximity, but mental connectedness enables and supports information and knowledge sharing.
• Openness and good communication skills turned out to be the most important additional characteristics necessary in virtual project settings.
• Interdisciplinary and multicultural virtual projects represent ideal learning environments, but tend to be more challenging and stressful than its traditional counterpart.
• A project team's self awareness / assessment regarding their knowledge management potential and status often don't reflect empirical reality.
• SNA supports the identification of important gatekeepers or knowledge brokers and allows the visualisation and optimisation of a project manager's social connectivity.

Source: Developed for this research

Nearly all interviewees valued their projects as ideal learning environments (see Table 5-19). Nevertheless, the overall picture demonstrated that virtual project work, in particular in multi-cultural and interdisciplinary settings, is more demanding and challenging than its traditional counterpart. Case analysis revealed a broad spectrum of project-related approaches, ranging from widespread highly individual 'on-demand' knowledge acquisition up to some institutionalised and systematic sharing processes. Based on several feedback meetings with participants, where the case-specific findings have been presented, care has to be taken regarding the context-related discussion. Some people have the tendency to construct neat argumentation models, trying to justify result patterns and/or use them politically based on their 'hidden agenda'. In addition, one has to avoid to slip into some sort of pseudo-rational micro-assessment (e.g. referring brokerage measures), but always trying to blend complemental sources of evidence, thus keeping a holistic perspective.

This section presented a cross-method synthesis of obvious patterns and tentative relationships, trying to find and elaborate on links between socio-cultural aspects like trust, language or barriers and network-related variables like information / knowledge exchange, accessibility and contact frequency. Next, conclusions referring to the five investigated research issues will be presented and discussed.

7.3 Conclusions about the research issues

This section presents relevant findings for each research issue within the context of this and prior research examined in chapter 2. Thus, it will be discussed how this research agrees or disagrees with previous concepts and areas about which there were some speculations in the literature, but no empirical testing. Moreover, new domains or aspects which had not been addressed in previous research will be presented and put into context.

7.3.1 Trust – An influential facilitator for 'virtual' knowledge sharing

More than 90 per cent of the interviewed case participants clearly indicated that they could rely on those with whom they are working (see Table 5-8). In addition, 75 per cent stated that they were satisfied with their virtual work and no evidence from case interviews could be found proving decreased team member productivity compared to traditional settings (see Table 5-19). These findings relativise studies by Handy (1995b), Nohria and Eccles (1992) as well as Victor and Stephens (1994), who argued that the dispersion of team members may engender low levels of trust and cooperation, a reduction in employees' well-being and satisfaction and may ultimately reduce the overall ability of the team to perform adequately (see chapter 2.6.1). Focusing on the lack of social context, which may alter or hinder the process through which team members develop trust (Kayworth & Leidner 2002; Luhmann 1979), qualitative results showed that reliability, consistency and responsiveness are influential promoters of trustful work environments (see chapter 5.4.1). Further, transparent dealing as well as congruence between a person's words and actions are equally important. Quantitative SNA findings (see Table 6-18) identified a significant correlation between physical proximity and information / knowledge sharing for 50 per cent of the investigated virtual project environments, thus proving the notion that 'trust needs touch' in these work settings (Handy 1995b).

Meyerson et al. (1996, chapter 2.7.3) argued that people in project teams deal with each other more as roles than as individuals. A form of depersonalised trust may develop based on category membership, i.e. such trust grows independent of the object of perception. This aspect could be supported by interview findings (see Table 5-8) showing that initial trust in many cases is based on organisational membership (As one interviewee said: "I can trust the partnering organisation, but I hardly can trust the often changing delegated team members") as well as a team member's [anonymous] competence and experience profile. Further, these findings affirms studies by Koskinen et al. (2003), who urged that there is no time in virtual project environments to engage in the usual forms of confidence-building activities that contribute to the development and maintenance of [interpersonal] trust. In contrary, Creed and Miles (1996) as well as Handy (1995b) highlight the importance of interpersonal trust as implicit mechanism for control and coordination in virtual settings. In this context, further analysis of findings revealed more differentiated forms of trust (see chapter 5.4.1), thus results suggested that in technical (or operational) environments task-related trust is more prevalent than its interpersonal form, hence team members focus more on individual competence and experience, when assessing the trustworthiness of individuals. On a more managerial level though, interpersonal trust seems to be the primary from of trust, hence especially in these settings good (prior) business or personal relationships are important prerequisites for an individual's influence / success in virtual project settings.

Koskinen et al. (2003), Huemer et al. (1994) as well as Weick et al. (1995) highlighted that the trust emphasised in virtual project teams is a unique form of collective perception and relating that is capable of managing issues of vulnerability, uncertainty, risk and expectations. Interview findings supported that point of view, where interviewees linked the aspect of trust with safety feelings, thus "is this team environment a safe place for me to disagree or come up with a wild idea?" Koskinen et al. (2003) presented the concept that the greater the level of trust, the greater the level of accessibility and the better the opportunities for tacit knowledge to be transferred. In this context, accessibility determines the type and frequency of interactions that occur and can be defined as an individual project team member's perception of his/her liberty or ability to approach or interact with another project team member. SNA findings (see Table 6-18) supported the described concept by proving a hight correlation between a team member's accessibility and information / knowledge sharing activities for all investigated cases. Moreover, a strong positive connection between team member's prestige and influence (thus implicitly indicating trust) and communication activity (see Table 6-16) affirmed statements by Jarvenpaa and Leidner (1999), who claimed that trust among peers in a virtual setting leads to more effective communication, collaboration and mutually acceptable ways of coordinating work. The fact that interview findings showed that a direct person-to-person contact is not always necessary, thus trust can be established using acquaintance e.g. via a person's boss or colleague (see chapter 5.4.1), supported Milgram's (1967) 'small world' phenomenon, hence two unrelated individuals can connect with each other through their acquaintances, the acquaintances of their acquaintances, and so on. In essence, and referring to O'Hara-Devereaux and Johnson (1994), the investigation of this research issue showed that very often psychological distances between virtual team members and not physical distances are the most influential factors.

In summary, qualitative and quantitative findings not only supported sources from the literature review, but could provide compelling empirical evidence regarding more or less theoretical notions from an academic origin, thus highlighting the influence of trust on the creation and exchange of knowledge within virtual project teams. Moreover, conclusions could be strengthened by corresponding SNA results e.g. the link between trust and accessibility, thus adding new and promising dimensions to this somehow 'opaque' aspect of virtual work environments. Next, the second research issue 'Language and vocabulary' will be discussed.

7.3.2 Language and vocabulary – The difference between communicating and understanding each other

Kayworth and Leidner (2000; 2002), Hightower and Sayeed (1995) as well as McGrath and Hollingshead (1994) identified several communication-related factors representing potential inhibitors in virtual sharing processes, which could be validated using related research findings. Hence, two thirds of the participants experienced communication problems in their virtual projects based on different vocabulary or language and focusing on knowledge sharing and utilisation 42 per cent of the interviewees reported negative experiences or problems in this area (see Table 5-11). Feedback from experienced participants disclosed that communication problems in multicultural and interdisciplinary project environments are common and need to be addressed in a consistent and fast manner (see chapter 5.4.2), thus supporting statements by Kiesler and Sproull (1992) as well as Warkentin et al. (1997). They argued that since communication media may differ in their ability to convey 'social presence', information-rich nonverbal cues, such as facial expressions, voice inflections, and gestures, may be lost or distorted through IT/CT that lack the social presence inherent to face-to-face environments. Findings revealed that especially in multicultural project settings a broader description, explanation and discussion of used concepts, issues and words is necessary to avoid misinterpretations and subsequent tensions or conflicts. Referring to Dubrovsky (1991) interview findings supported the notion that important social/contextual information, e.g. a member's social status in Asian project settings, may be lost or distorted in virtual team environments characterised by high levels of anonymity. Individual SNA results (see Table 5-10 and section 6.2.5) proved that language and vocabulary related imbalances e.g. focusing on new team members, hindered the development of relational links with other individuals and negatively affect morale and decision-making quality (Walther & Burgoon 1992).

Despite the mentioned communication problems, interview findings showed that 63 per cent of all participants stated that they share a common language in their virtual project team - technically as well as personally (see Table 5-11). Focusing on knowledge exchange and referring to Nonaka and Takeuchi (1995) this sort of shared language enhances combination capability e.g. the development of new concepts or narrative forms. This finding further related to Nahapiet and Ghoshal (1998), who stressed that the use of a common language facilitates a team's ability to gain access to people and their information. In this context, qualitative findings showed that native [English] speakers gained leadership positions in teams, partly because of their ability to express ideas and concepts more eloquently (see Table 5-10). Blackler et al. (1998) claimed that language does not passively mirror the world, but rather speech is a practical act that shapes and negotiates meanings. Nahapiet and Ghoshal (1998) further elaborated on this aspect arguing that to the extent that language and codes are different, people were kept apart and access was restricted. Both arguments could be supported by several case- related interview results where insufficient language skills, different vocabularies as well as a varying interpretation (Meaning) of even single words (e.g. "must", "could" or "should") hindered effective communication and sharing activities (see Table 5-10). Solomon (1995) equally described this phenomenon, thus as team members communicate, they will tend to filter information through their inherent cultural biases, thereby giving rise to a potentially broad range of misinterpretations or distortions. Several interviewees named different perceptions and interpretations as important obstacles and highlighted the need for context analysis capabilities (language, culture, vocabulary) as important prerequisite for effective [client] communication. These findings affirmed Berger and Luckman (1967) as well as Pondy and Mitroff (1979) who said that language influences our perception and that a shared language, can provide a common conceptual apparatus for evaluating the likely benefits of information / knowledge exchange and combination.

The majority of the interviewees supported the notion that documented knowledge is sometimes not easy to understand (see chapter 5.4.2). This finding affirmed Snowden

(2002) as well as Fernie et al. (2003), who urged that to fully understand the nature of knowledge transfer one has to take into account the issue of content and context. He further explained that the level of abstraction can be regarded as an important determinant of knowledge transfer, much ignored in many knowledge management models (see chapter 2.4.3). This issue directly relates to identified team-based knowledge asymmetries, where results from qualitative data collection identified communication / sharing problems based on different knowledge levels of collaborating team members (see Table 5-10). In this context, Nahapiet and Ghoshal (1998) stressed that in order to combine the information gained through social exchange, the different parties must have some overlap in knowledge. This aspect mirrors case-related evidence, where project partners were not able to apply shared explicit knowledge in their organisational setting because of significantly different knowledge repositories, cultures and operational policies and processes.

It came apparent that synchronous communication activities like meetings, telephone conferences or even online chats put additional stress on (foreign) participants because of existing (poor) language skills and 'invisible' cultural norms (see chapter 5.4.2). Thus, these team members tend to prefer an asynchronous communication medium e.g. email. This aspect related to Hiltz and Johnson (1990), who explained that individuals in asynchronous environments may tend to send longer, more carefully crafted messages, which may place an even greater information processing burden on team members as they attempt to decipher and act on these messages. In this context, studies by Duarte and Snyder (1999) as well as Hofstede and Bond (1998) highlighted that members from high-distance cultures may participate more freely with asynchronous technologies. Several participants highlighted the necessity to clearly indicate new and/or relevant knowledge to avoid endless searching of databases or documents. This result supported Jaafari and Manivong (1998), who urged the implementation of a dedicated protocol at the outset of a project to facilitate communication and integration of team input.

In summary, the identified problems affirmed Tuomi (1999 as cited in Fong 2003), who emphasised the difficult role of language as a 'repository of culturally shared meaning', critical for any knowledge creation theory, for multidisciplinary [and multicultural] project teams. Given the growing popularity and necessity of this sort of work environments and referring to Snowden (2002 – see chapter 2.4.1), it became clear that many organisations tend to look at the problem through the filters of the old thus keeping the old models and old language in place. The investigation of this research issue proved the relevance of a common language and shared vocabulary in virtual project settings. Most of these work environments are characterised by their multi-cultural and multi-language layout, thus potentiating challenges known from traditional settings. Therefore the common management habit to launch new initiatives, relying on the philosophy that more communication and collaboration are better (Cross & Parker 2004) has to be substituted by a much more qualitative approach targeting the nature, abstraction level and distribution of project language and related vocabulary. Next, findings referring to the aspect of ‘Informal networks’ will be contrasted with the body of knowledge as presented in chapter 2.

7.3.3 Informal networks – The ‘hidden’ power in team-based knowledge sharing

Statistical results derived from case interviews showed that 75 per cent of the interviewees claimed that they were able to identify informal structures within the project team (see Table 5-13). This finding concurs with a disagreement of most participants regarding the statement that it is not possible for an individual to sufficiently identify informal networks. Both aspects contrast with statements by Galbraith (1995) and Heckscher (1994) who stressed that executives seem to do relatively little to assess and support critical, but often invisible, informal networks in organisations although actual research indicates ways managers can influence informal networks at both the individual (Baker 2000) and whole network levels (Krackhardt & Hanson 1993; Krackhardt 1994). Focusing on the question whether formal or informal structures are more suitable for knowledge sharing, statistical results showed a quite balanced feedback, nevertheless individual case results (see Table 5-13) proved the importance of informal networks as influential factors in these particular settings. One participant highlighted that “without informal networks the project becomes in island, not being able to adjust and modify as the organisational environment changes” and another added that “without formal networks we couldn’t do what we are here for”. Both findings supported Podolny and Baron (1997), who stated that informal networks also transmit social identity (norms) and social support. Statistically the majority of participants assessed the formal project as the primary driving force within their project environment and not informal groups or networks. This result contradicts Quintas et al. (1997), who proclaimed that social networks were identified as the most important vehicle for information and knowledge exchange, with team members heavily reliant upon colleagues, friends and ex-colleagues.

Hansen (1999), Lin (2001) and Podolny and Baron (1997), highlighted that performance implications of effective informal networks can be significant at the individual, team and organisational level (see chapter 2.5). Interview findings showed that informal groups or networks represent a safe and secure environments, which are used by team members as discussion forum for new or risky thoughts and ideas before presenting them to the whole project team (see chapter 5.4.3). In addition, participants stressed that things progress faster and easier in these environments; an issue, which relates to a shared language and common mindset. This result supports Allen (1977) and O'Reilly (1982), who stated that individuals have a general preference for obtaining information from other people, rather than from documents. Further, this finding positively relates to Granovetter (1973), Lave and Wenger (1991) as well as Szulanski (1996) who stated that the aspect of those you know often has a great deal to do with what you come to know. Nevertheless other findings showed a more negative attitude, thus participants perceived informal networks as cliques with a “Knowledge is Power" mentality and feared that the project may suffer. One potential drawback of informal structures is a loss of transparency and knowledge sharing efficiency, because the rest of the formal project team will not necessarily profit from this gain an aspect widely neglected in literature. Another finding with no equivalent in the reviewed literature was that notion that shared information and knowledge within an informal context has a higher quality and relevance compared to its formal counterpart (see Table 5-13).

Stevenson and Gilly (1991 – see chapter 2.5.2) stressed that network ties are useful predictors of how information flows in organisations and can be better indicators than formal structures. This statement could be validated several times throughout this research. Social Network Analysis has been used to visualise each project team’s information and knowledge sharing activities and to draw up a comparison of an individual’s informal assessment (Prestige, Activity and Influence) and his formal team role (see Table 6-16). Additional evidence from depth interviews emphasised that informal networks are good for immediate problem solving, but formal networks are better for [systematic] knowledge transfer. One participant suggested that projects should be started and planed with a more formal structure, the tasks distributed and more informal networks should be used to actually solve the tasks (see chapter 5.4.3). Ahuja and Carley (1999) highlighted the necessity to monitor and manage communication structures and to align the communication structure to the task characteristics. In this context, SNA findings like the project-related visualisation of communication activities (see graphs in chapter 6.2) as well as the identification of specific collaborative subgroups (see appendix O) and related indices proved to be a good basis for reflective activities and subsequent corrective actions.

Interviewee feedback stressed that informal groups within a project setting may have a relative high degree of inward communication and therefore, from a time and energy point of view, the project itself may suffer. Although the relationship between internal versus external communication focusing on formal sub-units has been investigated by calculating the E-I Index (see appendix N for details), its informal counterparts could not be analysed due to the fact that their identification was not within this research's focus. Mead (2001) argued that dense networks have a high degree of teamwork because there is considerable communication between all members whereas loose networks are typically comprised of isolated individuals who like to work autonomously (Garton et al. 1997). Given the insufficient body of knowledge regarding network analysis of virtual project teams in combination with a small team size of around 14 individuals, the expressions 'dense' and 'loose' are quite relative. Although SNA findings (see appendix Q) showed a specific distribution of results with an average density index of around 2.2, a reliable relationship between density and the intensity of communication [and knowledge sharing] could not be identified. In this context, actor related indices like Degree Centrality or Simple Prestige proved to be better predictors.

The theoretical rationale of a network perspective on virtual project teams is the argument that behaviour is primarily affected by the kinds of ties and networks in which people are involved and to a lesser extent by individual attributes (Wellman & Berkowitz 1988; Wasserman & Faust 1999). Brass (1984) and Ibarra (1993) added that these types of relationships directly enhance or constraint access to valued resources and affect the nature of knowledge sharing activities (Hansen 1999; Teigland & McLure Wasko 2000). The case-related investigation of SNA variables 'Knowing' and 'Access' allowed the positive validation of Contractor et al (1998), who claimed that the extent that an individual's "mental knowledge map" matches the actual knowledge network, directly affects their ability to forge relationships, and to gain access to new sources of knowledge. In addition, findings referring to the SNA variable 'Risk' supported statements by Cross et al. (2002a), who stressed that when a person asks another person for information or knowledge, they inherently become vulnerable because "help seeking implies incompetence and dependence, and therefore is related to powerlessness." Related results showed that the perceived level of risk and the extent of sharing are related in an opposing manner, thus the lower the risk the greater the exchange of information and knowledge and vice versa.

In summary, the discussion showed that informal relationships and networks represent an important vehicle for information and knowledge exchange, thus enhancing project agility and responsiveness. Nevertheless care has to be taken to balance the informal and the formal, more systematic and structured, side of the sharing process, because otherwise relevant [informal] knowledge and expertise couldn't be identified, captured and shared with a wider audience e.g. non-members of the informal circles or other projects. Despite the selective awareness of their potential usefulness neither extant knowledge management nor project management frameworks address informal networks sufficiently and provide the necessary methodological and procedural guidelines for project leaders. Next, the fourth research issue 'Boundaries' will be addressed.

7.3.4 Boundaries – Barriers or necessary 'modulators' targeting project-wide learning processes

Findings showed that *geographic boundaries* fostered the reluctance of individuals to contact other knowledgeable, but not collocated team members. In addition, the majority of interviewees highlighted the importance of physical proximity (especially in Asian cultures) regarding the development of interpersonal trust as well as focusing on the solution of complex technical or personal issues (see chapter 5.4.4). Both aspects affirmed Handy (1995b), Nohria and Eccles (1994) as well as Griffith et al. (2003), who stated that as teams differ in their amount of virtualness, so too do they differ in critical ways regarding the transfer of knowledge from their members to the team and to the involved organisations. Further support could be derived from the statistical analysis of interview summary questions (see Table 5-15), where results showed that knowledge can be best shared in close personal contact and that regarding complex issues team members definitely preferred a direct face-to-face communication instead of a virtual one.

Cultural boundaries were evident e.g. in case E where Asian members formed some sort of informal sub-group based on cultural background and similar strategic intentions. In this context, Duarte and Snyder (1999) identified three categories of culture that can affect a virtual team, thus national (Hofstede & Bond 1998), organisational as well as functional culture and proposed technological considerations to facilitate communication (see Table 2-5). The difference between teaching and learning cultures (Keesing & Strathern 1998) could be investigated in case F where at corporate head quarters a teaching culture prevailed, thus project-related knowledge demands were characterised by their seeming certainty or explicit knowability. In contrast, at the foreign main project site the culture had a more networked, fluid and tacit character. Here team members had to deal a lot more with ambiguity and uncertainty originating from the project delivery process as well as from the surrounding environment. Expert language and the time and basic skill it takes to acquire that expert language including the ability to use explicit specialist terminology creates a *language boundary* for new team members (Snowden 2002). Interview feedback clearly proved that this sort of constraint hinders the necessary context building in such a way that the 'correct' reassembly and arrangement of shared knowledge is disturbed. In this context, one participant said that it took him four months to get used to the team's language and specific vocabulary, before he could contribute effectively. Because language and culture are strongly interconnected the Cynefin model (Snowden 2001; Snowden & Kurtz 2003) could be used as a 'gauge' to categorise project environments and the plan and monitor transitions betweens different domains (see Figure 2-6).

Becker (2001 – see chapter 2.4.5) stated that if knowledge retention and sharing are of interest the legal definition and *legal boundaries* of an organisation (see also remarks on structural boundaries) are of no help; the relevant boundaries have to be given by the transferability of knowledge. Despres and Chauvel (1999a) added that an individual's thinking and action create a context and second, the identity boundaries they fix around legal entities are social fictions contextually speaking, given the wide-ranging work interactions people have. Interview findings disclosed that the majority of knowledge management frameworks, policies and processes have been planned and implemented with a sole fixation on the legal, formal project organisation. The specific context and nature of relevant knowledge objects, thus either implicit or explicit, and their transferability were not taken into account. Especially in projects where contractual regulations involve the transfer of technological know-how these legal boundaries deserve a great deal of attention. As already addressed in section 7.3.1, O'Hara-Devereaux and Johnson (1994) pointed out that very often psychological distances, thus *psychological boundaries*, and not physical distances between virtual team members are the most influential aspects in information and knowledge sharing processes. Some individuals may not feel comfortable revealing their own lack of knowledge on a given topic, whereas alternatively, people one asks for information may make someone feel excessively indebted to them (Hofstede & Bond 1998; Duarte & Snyder 1999). SNA findings (see appendix O) for variable 'Cost' (see Table 5-1) depicted the extent to which participants felt that seeking information or advice from other team member's was perceived as was costly. In this context, five out of six cases exhibited individual team members with a visible difference between a potential accessibility of their knowledge and the incurred cost perceived by others.

Fong (2003 – see chapter 2.3.2) emphasised the importance of boundary crossing in knowledge creation and identified two types of boundaries as affecting the progress and success of multi-disciplinary knowledge creation. The first boundary was between team members of different disciplines and could not be observed directly in this study, although one interviewee stressed that multi-institutional and interdisciplinary environments make virtual work more difficult. The second [*structural] boundary* existed between client, consultant and contractor, and could be identified in several case settings, resulting in several degrees of integration (see chapter 5.4.4). This finding concurs with evidence that organisation-related grouping or conglomerating of project staff represents an obstacle for effective knowledge sharing activities. Despite these barriers Quintas et al. (1997) too highlighted the importance of boundary crossing, where team members are able to exchange and combine knowledge (Nahapiet & Ghoshal 1998). Interview findings point out that there is a difference between people who just do their jobs and boundary spanners who can bring in new and on-demand knowledge from other areas, thus strengthening a project's reactiveness in dynamic and challenging situations (see chapter 5.4.4). In addition, participant feedback stressed the significance of project managers to be socially connective, thus linking small collocated cliques within the surrounding virtual fabric, especially in multicultural and interdisciplinary environments. This affirmed Lipnack and Stamps (1999 – see chapter 2.7.1.1), who pointed out that the virtual team leader needs to link the distributed minds (knowledge workers) together without superimposing his/her own mind on top of the team members. Further support could be gained using quantitative SNA results insofar as Table 6-17 summarised case-related types and quantities of brokerage positions, thus clearly indicating those important boundary-spanners mentioned above.

Reflecting on the two previous paragraphs, Snowden (2002 – see chapter 2.4.5) said that maintaining boundaries between communities can be vital in ensuring knowledge exchange. This statement was supported by interview findings where the necessity of clear demarcation of responsibilities was highlighted to ensure the control of unique knowledge within a virtual project environment (see Table 5-14). In this context, Snowden and Kurtz (2003) found that in using boundaries as part of the Cynefin framework different people, with different training and personalities, seem to benefit from different uses of boundaries. People who are used to classifying items into categories benefit from removing boundaries. However, people who are used to thinking in a more fluid way - about gradients rather than boundaries - seem to benefit more by constructing boundaries than by removing them. As Cross et al. (2002b) emphasised, an assessment of junctures in networks that are fragmented across functional or hierarchical boundaries can be informative for social or technical interventions that help to integrate disparate groups and hence preparing the ground for effective knowledge transfer. Findings and insights derived from SNA graphs (see chapter 6.2) as well as from additional indices allowed the identification of informal sub-groups, which in turn supplemented and strengthened the interpretation of collected qualitative case data.

In summary, the investigation highlighted the ambivalent character of boundaries as not only as potential hindrance, but as a necessary part of project-related knowledge processes. Boundaries can define separate perceptual systems e.g. targeting different cultures, languages or functional communities, thus providing the necessary framework for the development of meaning. In this context, Snowden and Kurtz (2003) highlighted that different people seem to benefit from different uses of boundaries. People who are used to classifying items into categories benefit from removing boundaries. However, people who are used to thinking in a more fluid way - about gradients rather than boundaries - seem to benefit more by constructing boundaries than by removing them. Next, findings referring to the research issue “Risk” will be discussed within the context of the reviewed literature as well a focusing on new ideas and concepts uncovered during this study.

7.3.5 Risks – Share and collaborate today and compete tomorrow

Fong (2003 – see chapter 2.3.2) urged that despite the existence of little competition among team members, external competition could act as a double-edged sword in the knowledge-sharing process and that sharing important market or design knowledge could lead to imitation by competitors, possibly even resulting in project poaching.

Based on research findings, Fong's statement has to be relativised, because sometimes internal competition and power struggles between departments are more prevalent than their external counterparts. Knowledge asymmetries (Fransmann 1998) between internal sub-teams or external project partners could be confirmed by the fact that the majority of case participants rated collaborative partners as more experienced in certain areas. This qualitative finding was supported by quantitative results derived from Social Network Analysis, where case data referring variable "Value" (see Table 5-1) was used to visualise a project team's knowledge related 'value net' and to calculate appropriate SNA indices (see appendix O and Q). Macneil (1978) urged that the intention to cooperate has to be translated into a relational contract that broadly outlines areas of exchange and codes of conduct. Loebbecke and van Fenema (2000) further argued that project partners need adjustable and flexible control strategies. Interview findings for case E showed that some of the involved airline companies held internal briefings before important conference calls or meetings to discuss their strategic position and to decide what knowledge or information to share and what not to share (see chapter 5.4.5 for details). Furthermore, no evidence could be found in any of the cases that project partners systematically and comprehensively addressed, fixed and controlled the identification and exchange of relevant information or knowledge.

54 per cent of the interview participants said that they were familiar with knowledge management is a term and concept. This finding surpassed values published by Fong (2005a), who found in his study that around 40 per cent of survey respondents did know about knowledge management. Referring to a potential diffusion of knowledge, the statistical analysis of interview findings (see Table 5-17) showed, that more than two thirds of the interviewees claimed that they were not aware of any knowledge losses with respect to their actual project, although 50 per cent stressed that knowledge is always lost in either virtual or traditional project teams. In particular, feedback showed that one parent organisation calculated the financial risk of losing intellectual capital through retirement equals a sum of 300 Million US$ within the next five years and that no adequate retention processes are in place to cope with this development. One interviewed expert said that it is more the question of how people are strategically aware of what they are doing with their knowledge and how much attention they are giving this issue in the context of the project team (see chapter 5.4.5). This finding relates to Loebbecke and van Fenema (2000 – see chapter 2.7.5), who emphasised that parties may have, deliberately or unconsciously, different perspectives on the direction and boundaries of the knowledge component in their

exchange relationship. This aspect in turn influences a team member's perception regarding the project's knowledge repository, because first it is likely that he is only aware of a small fraction of it and second, what might be valuable knowledge for one person can be useless information for another and, thus slips out of his mental focus.

Jaafari and Manivong (1998) emphasised that information on operability, occupational health and safety, quality and stakeholders' interest must be evaluated using a reflective practice approach. They suggested setting up a clear protocol for each project at the outset to facilitate the communication and integration of team inputs into the project model. Interview findings provided compelling support for this notion because evidence could be found that the necessary sharing (codification) of knowledge has not been considered in the project assignment (no clear contractual regulations) and that these activities are therefore viewed and handled as additional, unplanned work (see chapter 5.4.5). Bal and Teo (2001) as well as Henry and Hartzler (1998) highlighted the need for a clearly communicated and understood statement of direction and Duarte and Snyder (1999, p. 94) added that the lack of physical contact in virtual teams may "erode meaning and understanding and make the link between charter and work more tenuous".

Additional interview findings showed that in most case environments reflective (double loop) learning was not valued and not implemented systematically, thus knowledge was not secured and therefore lost, because of a primary focus on immediate (task or project-related) problem solving, however neglecting its organisational and long term importance as 'fuel' for organisational learning processes (see chapter 5.4.5). This qualitative finding related to Bredillet (2004), who characterised organisational operations with a single loop approach and project activities with double loop learning (see Table 2-3 for details). Thus in essence, many companies are still using primarily organisational single loop approaches (structures, processes, policies or 'Best Practices') in virtual project settings, neglecting their totally different character and context. The investigation of SNA results supported the verification of Cross et al. (2002a), who emphasised that when a person asks another person for information they inherently become vulnerable because "help seeking implies incompetence and dependence, and therefore is related to powerlessness." In this context, SNA findings (see appendix O and Q) indicated that in five out of six cases at least one team member showed a discrepancy between his [knowledge] accessibility and the perceived risk or cost for other team members in trying to access this knowledge.

Several findings with no reference in the reviewed literature could be identified: First the fact that in a multi-institutional and multicultural project setting (Case B) insecure property rights and misguiding governmental regulations represent an potential risk regarding the ethical side of knowledge transfer (Keyword: Ethical responsibility). Thus, what might be ethically ‘correct’ in one country e.g. in genetic research is strictly forbidden in another country. Second, interview findings highlighted the need to insure the technical and scientific integrity when translating codified knowledge in global work settings. A third potential project risk was the discovery that internal organisational guidelines of involved project partners sometimes overruled project issues and thus hindered the realisation of agreed upon project targets (see Table 5-16).

In summary, the investigation of research findings showed that systematic and jointly agreed upon regulations focusing on knowledge-focused coordination / control mechanisms were not in place in any of the investigated cases. Given the constraints associated with virtual work environments the visualisation of team based knowledge awareness using SNA proved an only insufficient consciousness resulting in incomplete or false mental knowledge maps. The tacit nature of important knowledge resources makes it even more complicated to detect uncontrolled knowledge diffusion processes. In this context Malhotra’s (2000b) suggestion for self-control as the driver of human actor’s behaviour and actions instead of an unquestioned adherence to pre-specified rules or procedures is somewhat debatable. It is questionable whether pure self-control is sufficient to regulate the ownership and sharing of accumulated project knowledge in highly challenging project settings like international consortia. Despite the finding that virtual projects can represent a comprehensive and fruitful learning environment, the investigation of this particular research issue uncovered several inhibitors and potential risks. New ways have to be found to balance expectations and requirements of the involved organisations and necessary knowledge-focused coordination mechanisms for the project itself. Next, conclusions about the research question will be discussed.

7.4 Conclusions about the research problem

The broad parametric basis used in this research, coped with the fact that socio-cultural aspects in knowledge management, require both incredible attention to minutiae and a comprehensive view of diverse, but related domains simultaneously. Although the comparison of findings with the corresponding body of knowledge referring the five research issues provided important conclusions targeting the clarification of the research question, several other influential aspects could be identified during this study. These subjects will now be challenged with evidence from the literature review and results will act as additional input for the development of a final conceptual framework encapsulating the achievements of the research.

Referring to *communication- / knowledge-related team roles* quantitative findings derived from SNA e.g. graphs or the calculation of brokerage positions (see Table 6-17) allowed the in-case investigation and validation of theoretical role definitions issued by Erwee et al. (2000), Roberts and O'Reilly (1978) as well as Tichy and Fombrun (1979), who identified four roles including a group member, a group linker or liaison, an isolate and a star (see chapter 2.5.3). Duarte and Snyder (1999) stressed that to ensure project success, the project leader or manager has to be able to influence the behaviour of others in his/her team. The calculation of specific case-related SNA indices (see Table 4-10) enabled the informal assessment of a team member's prestige, activity and influence (see Table 6-16) and provided support for the authors notion insofar as in all relevant cases the formal project leaders were rated as most influential players.

The importance of appropriate *skills and personal characteristics* was highlighted by Duarte and Snyder (1999) as well as Krogh and Roos (1996) who found that in order to ensure success in collaboration and coordination and in autonomy roles, virtual team members should posses extra competencies in addition to traditional team competencies. These statements could be supported by qualitative interview findings, where nearly all interviewees (95 per cent) emphasised the need for additional socia-cultural and technical skills focusing on knowledge management in virtual project environments (see chapter 5.4.6). Participants characterised the 'ideal' virtual team member as open minded, proactive, flexible and positive person with good communication skills. Despite these conclusions, several interviewees stressed that interpersonal (in contrast to technical) skills were not valued very much in their parent companies or organisations. In some cases specific selection criteria for project staff like technical skills or management experience were suppressed by mere 'availability' of sometimes underqualified personnel.

Referring to *explicit and tacit forms of knowledge* it became obvious that documented knowledge is often old and outdated and interview findings showed that the search for needed knowledge is often very time consuming (see chapter 5.4.6). This aspect in turn influenced the usage of search engines and knowledge databases by team members and one participant rated the overall efficiency of these databases in his project environment as less than 30 per cent. In contrast, Koskinen (2001 – see chapter 2.2.3) expressed that ideally a project would have much explicit knowledge and little tacit knowledge about the activities to be implemented, although this research suggests that its very often socially-enabled tacit knowledge, what ensures the necessary reactivity and flexibility in challenging project situations. Polyani (1962) highlights that tacit or unarticulated knowledge is always a precondition for explicit knowledge and Snider and Nissen (2003, p. 10) point out that "…formal knowledge such as documentation results from the work, whereas the (more) tacit knowledge flows associated with the vertical process enable the work to be accomplished in the first place". Both statements could not be verified by neither qualitative nor quantitative results, although it has to be admitted that the methodological framework was not tailored for this particular aspect. Further, interview findings showed that not all sorts or forms of knowledge can be shared virtually, thus the sharing of very unstructured knowledge needs a personal touch to be effective (see chapter 5.4.6). This finding related to Hayek (1945) who pointed out that the division of labour is accompanied by a division of knowledge as well and that there are clear limits to the centralisation (codification) of knowledge. In this context, Quintas et al. (1997) stressed that new or 'emergent' knowledge is generated through interaction and communication, but without mentioning whether synchronous or asynchronous modes should or must be used.

Focusing on *differences between virtual and traditional projects* settings, findings clearly supported the notion that constructs, policies and processes from hierarchical (traditional) structures often does not work in virtual team settings (see chapter 5.4.6). This fact supports Griffith et al. (2003 – see chapter 2.6.3), who stressed that as teams differ in their amount of virtualness, so too do they differ in critical ways regarding the transfer of knowledge from their participants to the team and to the involved organisations. Nevertheless, numerous interview participants valued virtual projects as ideal learning environments and statistical analysis supported this qualitative result by indicating that 96 per cent of the participants urged that they learned a lot in their project (see Table 5-19). This finding contradicts Bartezzaghi et al. (1997), who claimed that learning and projects are not a natural combination, since conflicts of a basic logical character are involved. In addition, qualitative findings emphasise that virtual work [and related knowledge management], compared to traditional settings, often puts additional stress on team members. This aspect was mentioned and elaborated in detail by Becker (2001), Fransmann (1998), Minkler (1993) as well as Tsoukas (1996). Statistical results further showed that 46 per cent of the interviewees perceived an increase in productivity since they started working in virtual environments. In contrast, two interviewed experts stressed that based on their experience only 5 out of 80 teams were successful from a teaming point of view and second, that virtual projects can be as effective as traditional ones, but it takes around three times as long (see chapter 5.4.6).

Referring to the *social side of knowledge sharing* in virtual project settings, participant feedback showed that people must have the chance to establish social relationships and these connections have to be reaffirmed regularly (see chapter 5.4.6). In this context, Hansen (1999 - see chapter 2.5.2) claimed that social networks also contribute to knowledge transfer within organisations. Interview findings urged the need for physical proximity to foster or even enable knowledge exchange and that individuals can obtain information not only from their personal social ties, but also from the social ties of those to whom they are related. This last result affirms Milgram (1967), who's research on the 'small world' phenomenon, showed that two unrelated individuals can connect with each other through their acquaintances, the acquaintances of their acquaintances, and so on. Qualitative findings provided clear support for Haythornthwaite and Wellman (1998), who said that the transfer of knowledge is an interactive process and quantitative SNA results provided detailed case-related evidence targeting Hansen (1999) as well as Teigland and McLure Wasko (2000), who both proclaimed that the nature of knowledge transfer is affected by the types of relationships people have.

Table 7-2: Summary of conclusions derived from SNA referring to case-related sharing processes

Conclusion	Type of Support
The extent to which a team member seeks information or knowledge from another individual is a positive function of the extent to which he *knows* the other person's areas of expertise.	**Full**
The extent to which a team member seeks information or knowledge from another individual is a positive function of the extent to which he positively *evaluates* the other person's knowledge and skills in domains relevant to his work.	**Full**
The extent to which a team member seeks information or knowledge from another individual is a positive function of the extent to which he has *access* to the other person's thinking.	**Full**
The extent to which a team member seeks information or knowledge from another individual is a negative function of the *costs* that he believes he will incur as a result of asking for help.	**Full**
Team member *gender* and *tenure* mediate information and knowledge sharing.	**No**
Team member *proximity* and *sub-group membership* mediate information and knowledge sharing.	**Partial**

Source: Developed from Borgatti and Cross (2003) based on field data

Referencing Stevenson and Gilly (1991), research has shown that network ties are useful predictors of how information flows in organisations and can be better predictors than formal structures. In this context, the executed Social Network Analysis (SNA) allowed an in-depth examination of *actual project-related sharing processes* using a specific set of variables and hypotheses (see Table 7-2). The investigation of cross-variable structural equivalence (see Table 6-18 for details) revealed a high positive correlation between all independent variables and the dependent variable (see definitions in Table 5-1). This finding supports Borgatti and Cross (2003) with the exception that the authors reported no correlation for the variable 'Cost'. Focusing on control variables, 'Gender' and 'Tenure' exposed no structural equivalence, thus these parameters had no measurable influence on project-based sharing behaviour. In contrast, significance levels of 'Proximity' and 'Sub-group' were positively liked in three out of six case settings, thus both of them showed relevant correlation with the team-based sharing networks. In contrast, Borgatti and Cross (2003) reported correlation only for control variable 'Proximity' within their two investigated case studies.

Reflecting on Krogh and Roos (1996) and Koskinen et al. (2001) findings supported their distinction between mere knowledge and personal competence as the superior or broader concept (see Figure 2-3). Socio-cultural and technical skills as well as personal characteristics like stress tolerance or openness are important moderators enabling an individual to get attuned and actionable with respect to a specific situation or context. This in turn allows the task-related recombination and adaptation of tacit and explicit knowledge fragments into a cohesive solution pattern and its subsequent execution. Relating research findings to the extant knowledge management life cycles or concepts presented in section 2.3.1, the criticism urged by Tuomi (1999) and Fong (2003) regarding Nonaka and Takeuchi's (1995) four modes of knowledge conversion could be confirmed. Particularly the Socialising and Externalisation phase are highly depending on socio-cultural variables like trust, language or abstraction level, whose adequate nature and homogeneity cannot be taken for granted in virtual project environments.

Focusing on the aspects of organisational learning as proposed by Sanchez and Heene (1997) as well as Bredilett (2004 – see Table 2-3) it came apparent that particularly the bigger [and more hierarchically organised] firms showed a 'theorising and codifying' form of learning bias, hence their culture could be characterised as teaching focused, applying best practices and organisational standards. Nonaka (1988) entitled this approach as a more top-down or deductive management philosophy in contrast to its bottom-up or inductive counterpart. The latter one could be identified in one of the smaller project teams involving a global NGO, where a learning-by-doing approach prevailed targeting the 'creative competence' (Bredilett 2002) of involved team members. Obviously a balanced strategy is necessary to ensure constant evolution in line with the experiences gained by individuals and to avoid fossilisation of the organisations knowledge repository (Bredillet 2002). In general, it seems to be difficult from a behavioural point of view for organisations or companies to combine their tight procedural project models with the more tacit and fluid side of knowledge management. The holistic investigation of research findings raised some criticism referring Bredillet (2004), who said that projects at the beginning generate information and create knowledge and then apply it in the later stage of the project. This statement neglects the fact that the actual application of knowledge can generate new and valuable insights, hence refining or even replacing 'old' components of the knowledge repository.

In summary, the multi-method investigation of knowledge creation and exchange in virtual project teams clearly proved the importance of socio-cultural factors. Although these 'soft aspects' are increasingly addressed and elaborated in extant literature, concepts and frameworks, the necessary awareness and – even more important – the operational implementation showed up to be only superficial and incomplete. Given the fact that knowledge has a natural decay factor a primarily codification oriented approach focusing on explicit knowledge is doomed to fail in these highly dynamic and heterogeneous work settings. To enhance reactivity and insure the necessary contextual quality knowledge will be more and more substituted by access to knowledge, thus a shift from ‘know how’ or ‘know what’ to ‘know whom’ (Becker 2001). The resulting synchronous knowledge transfer between sender and receiver, in comparison to an asynchronous reception of explicit knowledge objects, is much more flexible and thus efficient and copes much better with complex problems. In this context, the analysis of network-related parameters using SNA identified several promising dependencies between variables and socio-cultural factors like trust or informal networks which might add a new and more measurable dimension to the challenge of effective knowledge management in virtual [and traditional] project settings. Based on the described conclusions, the next section develops and presents the appropriate implications for theory in detail.

7.5 Implications for theory

This part will show that this research has not only made a significant contribution to knowledge in its immediate discipline/field “Knowledge Management in virtual project environments” as outlined in previous sections but also has implications for the parent disciplines as well as other related areas. Due to the different perspectives involved the final conceptual framework will be elaborated in three consecutive steps. First, inherent rational and informal dimensions will be contrasted and a project-related collaboration and content lifecycle as important prerequisite for information / knowledge sharing activities will be specified. Second, the representation of virtual projects as socio-culturally networked systems incorporating quantifiable parameters will be defined. Finally, the description of team-based knowledge transfer and moderation based on identified modulators complete the overall framework.

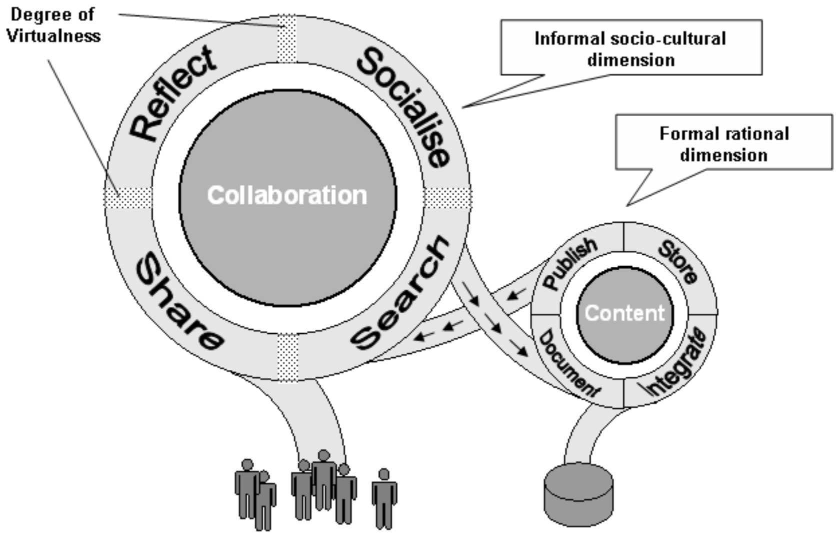
Table 7-3: Characteristics of project dimensions

	Formal rational dimension	**Informal socio-cultural dimension**
Epistemology	Positivistic	Constructivistic
Type of context	Closed	Open
Type of control	Compliance	Commitment
Flexibility	Low	High
Level of structure	High	Low
Way of gathering information / knowledge	Rational	Relational / Intuitive
Way of processing information / knowledge	Rule-oriented	Reflective

Source: Developed for this research

Based on the research findings each project environment is founded on two different dimensions, thus the formal rational dimension and the informal socio-cultural dimension (see Table 7-3). Within its well-defined context, the *formal, rational dimension* represents a positivistic environment where there exists a single, objective truth with clear relations of cause and effect. In contrast, the *informal, socio-cultural dimension* reflects a more constructivist worldview with several, sometimes competing truths. Referring to Gustafsson and Wikström (2005), information in this informal socio-cultural dimension is not information by itself, but is defined by the actual context representing the frame of reference in which information is seen. Information becomes informative or relevant knowledge only if the actor perceives it to be so (Nonaka & Nishiguchi 2001). Formal, bureaucratic structures reduce the need for communication and can maximise project efficiency in stable environments, whereas when the environmental conditions are very dynamic and complex, an informal, ‘organic’ structure supports the increasing demands for communication and allows the improvement of a project’s integrative capability.

Figure 7-3: Knowledge focused collaboration and content lifecycle in virtual project teams



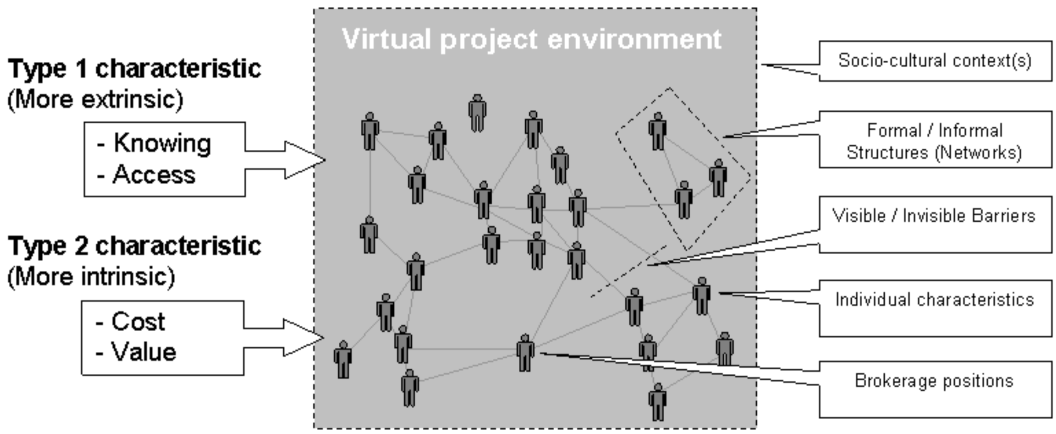
Source: Inspired by Opentext (2005)

On a more operational and procedural level, the described dimensions are mirrored by two project-based lifecycles, thus collaboration and content (see Figure 7-3). The size of the lifecycles reflects their importance referring effective team-related information and knowledge sharing activities. This research showed that the capability to create knowledge is not just with an individual but predominately in the interaction of team members with others and the environment. This notion concurs with Liebowitz (1999), who argued that in the KM field 80 per cent is people and process / culture and the other 20 per cent is technology. Focusing on the *collaboration lifecycle*, the process starts with a Socialising Phase where, based on individual expectations, perceptions and trust, relationships start to develop [or diminish]. These relationship patterns provide the necessary repository for the following Search Phase, where - guided by project tasks, context and specific situation - requests for information or knowledge take place. If the petition is successful, the desired information or knowledge asset is exchanged during the Sharing Phase. Throughout the Reflection Phase the nature and the success of the interaction is judged, which in turn adjusts the relationship between ‘provider’ and ‘receiver’ and recalibrates the scope and direction of future requests.

One important moderator pertaining the four interrelated phases of the collaboration lifecycle is the degree of virtualness, because - as research findings clearly showed – aspects like proximity, boundaries, language or communication media can significantly influence knowledge management in virtual project settings.

The formal, rational project dimension is reflected by the *content lifecycle,* which involves the Documentation (Codification), Integration, Storing and Publishing of relevant documents, forms or other procedural objects. Both lifecycles are interconnected, e.g. tacit knowledge acquired via collaborative activities can be codified and shared in documented form or team members can search for published information or knowledge using appropriate IT tools like web-based search engines or project portals. In contrast to its informal counterpart, the content lifecycle is much more insensible regarding the aspect of virtualness, hence available technologies can provide a suitable and efficient platform for content management in global, virtual project environments. Nevertheless, one has to remember that knowledge is most often expressed in action [and corresponding results], not words. Articulating the inherent information is probably many times more complicated, especially if one is asked to codify it in a way that the uninitiated and/or unskilled reader would understand. In addition, an exaggerated supply of un-framed content can easily lead to a tidal wave of information where it is almost impossible to find relevant information in a timely manner because of the highly situational characteristics involved.

Figure 7-4: Virtual project environment as socio-cultural knowledge network indicating descriptive aspects and quantifiable parameters



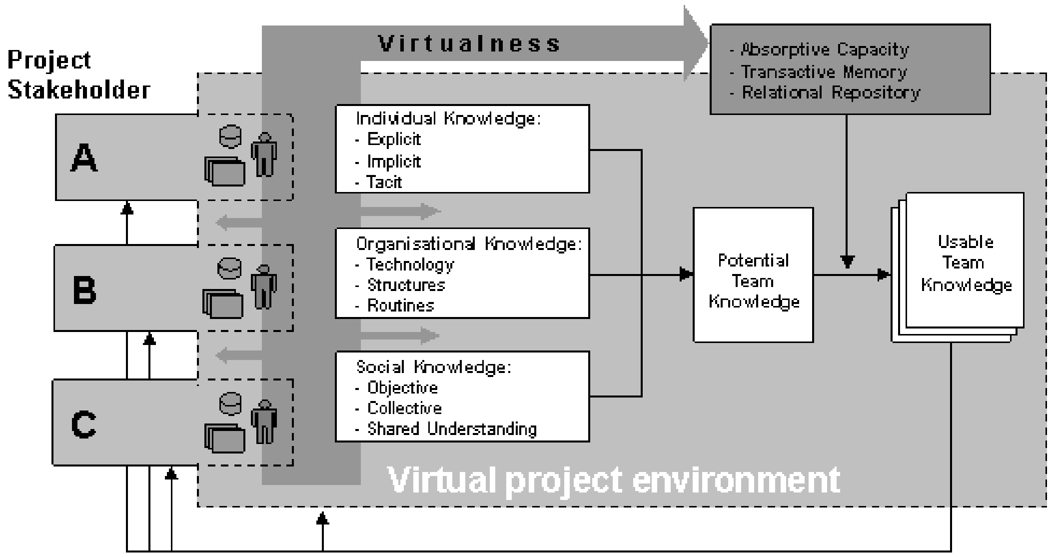
Source: Developed for this research

A virtual project team can be viewed as socio-cultural network founded on individual knowledge carriers (team members) and corresponding relationships (see Figure 7-4).

Ideally a virtual project environment mirrors one homogeneous socio-cultural context, but findings proved that very often several, sometimes competing systems coexist. These contexts might, but must not, fit with formal or informal networks. The type and quality of relationship is influenced by an actor's individual characteristics like competencies, skills or his cultural value system as well as by visible (e.g. geographically dispersed locations) and invisible barriers (e.g. lack of trust). Building on research findings the behaviour of information and knowledge sharing in virtual project settings can be predicted by four relational characteristics. The first two attributes 'Knowing', thus knowing what other team member knows, and 'Access', hence being able to gain timely access to a persons thinking [and knowledge], have been entitled as type 1 characteristics, because of their more extrinsic nature. In contrast, 'Cost', thus interpersonal risks a team member takes by admitting ignorance on a given topic, and 'Value', hence the extent to which another person's knowledge is important for someone's work, have been categorised as type 2 characteristics based on their more intrinsic nature. Type 1 characteristics are to a greater degree receptive concerning focused interventions, e.g. if the problem in a project team lies with the aspect of "knowing what someone knows" one might suggest expertise profiling systems or actions learning exercises.

Whereas, if difficulties exist with the access to information or knowledge, Communities of Practice or performance metrics in combination with a peer feedback process (Borgatti & Cross 2003) might be useful approaches. Despite their importance regarding team-based sharing activities, type 2 characteristics are not easy to assess or manage, because they are deeply rooted within a team member's socio-cultural awareness. Nevertheless research findings indicated an interesting affinity between the variable 'Cost' and the aspect of trust, which might represent a good starting point for further research. Despite this research's primary focus on virtual project teams, it has to be remembered that these environments do not represent isolated entities, but are embedded in – or at least linked with - several, often quite different, organisational settings. Figure 7-5 illustrates a framework describing different types of knowledge; moderating effects and the recursive link from resulting usable knowledge. Referring to Griffith et al. (2003) *individual knowledge* is made-up of explicit, implicit (could be made declarative) and tacit (non declarative) components. This type of knowledge is brought into the virtual team by project members delegated from different stakeholder organisations. In addition to this personalised form, *organisational knowledge* reflects the participating organisation's technologies, structures and routines and can have great relevance (e.g. when a project consortium is involved) regarding a project's performance and success. But on the other hand, the provision of key knowledge in today's competitive markets might be a double edged sword, because – as this research showed – suitable control mechanisms are often missing.

Figure 7-5: Knowledge representation and moderation in virtual project teams



Source: Developed from Griffith et al. (2003)

On the other hand, *social knowledge* is the collective type of knowledge that is publicly available or embedded within routines, culture or norms of a team (Spender 1996). In this context, the individual explicit type is linked with social objective knowledge and the individual tacit form corresponds with social collective knowledge respectively. The combinational process between individual, organisational and social knowledge is moderated by the degree of virtualness. In virtual project teams involving different organisations or partners these three knowledge categories join together to form *potential knowledge*. The transformation towards *usable knowledge* is influenced or modulated by the aspects of absorptive capacity, transactive memory and the team's relational repository, which in turn are impacted be the degree of virtualness. An individual's absorptive capacity is determined by his pre-existing stock of knowledge and is heavily depending on tacit knowledge (Cohen & Levinthal 1990; Griffith et al. 2003; Szulanski 1996).

Given the differential distribution of potential team knowledge throughout the virtual project space, a transactive memory system supports the application of potential knowledge towards performance (Liang et al. 1995). This process is driven by issues like shared experience, common language and joint decision making capabilities. Finally, the team's relational repository affects the information about and access to individual [and possibly also organisational] knowledge based on social person-to-person relationships, which are significantly influenced by interpersonal trust as well as a team member's risk awareness and commitment. Based on the varying intensity and influence of the three modulating aspects, the usable team knowledge is not one homogeneous pool of 'collective wisdom', but a multi-level knowledge repository, which might differ significantly based on organisational membership and an individual's socio-cultural context.

In summary, the stepwise representation of the conceptual framework builds both on a rational as well as a more informal project dimension. It elaborates the link between a collaborative and a content–focused lifecycle and describes virtual projects as socio-culturally networked systems using quantifiable parameters. The conceptualisation of an integrative approach focusing on knowledge representation and moderation in virtual project teams completes the overall framework. This new holistic model supports a deeper understanding of the complex, dynamic sharing processes in virtual project environments and provides a starting point regarding the optimisation of project guidelines and policies. Further, it might act as 'embryonic cell' fostering new and innovative perspectives focusing on knowledge management in virtual project teams. Next, implications for management practice will be presented and discussed.

7.6 Implications for management practice

One of the problems with many knowledge management methods and corresponding IT systems in general is that they have take up the neat and tidy computer model of information processing and tried to replicate it in human socio-cultural systems. Information and communication technologies became associated more with the capacity to capture and store information / knowledge than with their role in mediating communications between individual, social actors or groups. Knowledge management tools such as intranets, lessons learned databases and even community approaches are destined to underperform or fail if the underlying motivational and incentive characteristics are not sufficiently understood. Thus, in addition to technological solutions focusing on knowledge management in virtual project environments, social solutions have to be developed, effectively combined and implemented. In this context, the following paragraphs offer some guidance incorporating key research findings as well as suggestions based on the author's own consulting experience.

Initialisation

At the outset of a project common knowledge targets and strategies have to be defined and communicated as well as a clear protocol for a boundary spanning management of knowledge obtained. The definition of taxonomy ensures an agreed vocabulary of project-relevant topics, whereas ontology represents an agreement on the terminology (and sometimes the meaning) for project-based communication and action. [20] [21] Appropriate knowledge roles and processes have to be specified to allow the efficient integration of multi-disciplinary and multi-institutional team inputs into the project model. Care has to be taken not to implement processes and concepts designed for hierarchical work in virtual multi-cultural settings without sufficient reflection and/or adaptation. In addition, western style knowledge management approaches should be handled with sensitivity in Asian business environments because of the specific socio-cultural conditions involved. Team member selection criteria should be defined and followed consequently, the more 'virtual' and multi-cultural a project gets the more social-cultural and communication skills / competences are required. Training needs should be evaluated in a timely manner and relevant team members should be instructed and coached before key project activities commence. Especially when project partners are not well acquainted a systematic assessment of the project's environmental forces might yield valuable insights e.g.:

- What sort of decision systems prevail?
- What are the knowledge-related expectations of involved stakeholders?
- Are there any organisational silos?
- What are the KM maturity levels of involved project partners
- Are there known barriers and boundaries (Cultural, structural, language-related etc.)

On a more detailed level, the development of a project-related *knowledge map* can support the identification of relevant sources, flows, constraints and sinks of knowledge

[20] Taxonomies are a classification scheme used to categorise a set of information items. They represent an agreed vocabulary of topics arranged around a particular theme and can have either a hierarchical or non-hierarchical structure.

[21] Ontologies: see chapter 7.2

within the virtual work environment. Grey (1999) suggests several questions that should be asked to develop such a knowledge map:

- What type of knowledge is needed to do the work?
- Who provides it, where do you get it, how does it arrive?
- What do you do, how do you add value, what are the critical issues?
- What happens if you are finished?
- How can the knowledge flow be improved, what is preventing you doing more, better, faster?
- What would make your work easier?
- Who do you go to when there is a problem?

Socialising

At this stage social relationships are created / strengthened or deteriorated / destroyed, thus influencing the modulation of trust as well as the creation of informal communication channels through which knowledge can be shared. The overall process should be planed and managed deliberately, e.g. performing interactive exercises with team members as proposed by Cross and Parker (2004, p. 173). Their *Mystery Group Exercise* encourages team members to initiate relationships with the specific purpose of finding out their professional interests or experiences. If properly organised the exercise offers a low-risk environment, where people feel at ease while talking to others. This practice is particularly useful for helping newcomers break into groups of people who are already well acquainted. One important question in this context is: What relationships need to exist to leverage the virtual project team's collective expertise in the light of its heterogeneous stakeholder landscape? SNA can be used in this context to systematically and efficiently reveal the project's inner working and to identify starting points for project managers for effective interventions. The following Table 7-4 highlights areas and issues that might be addressed.

Table 7-4: Investigation of important network relationships

Collaboration	**Rigidity**
• Communication frequency • Information / Knowledge exchange • Problem solving • Innovation	• Decision making • Communicate more • Task flow • Power or influence
Sharing Potential	**Well-being and supportiveness**
• Knowledge awareness • Access • Engagement • Safety	• Linking • Friendship • Career support • Personal support • Energy • Trust

Source: Developed from Cross and Parker (2004, p. 147)

In complex and social-culturally challenging project settings it can be very helpful to designate a social project manager or 'project champion', thus someone who is respected by the majority of team members and stakeholders and capable of taking care of the more informal project dimension.

Search and Sharing

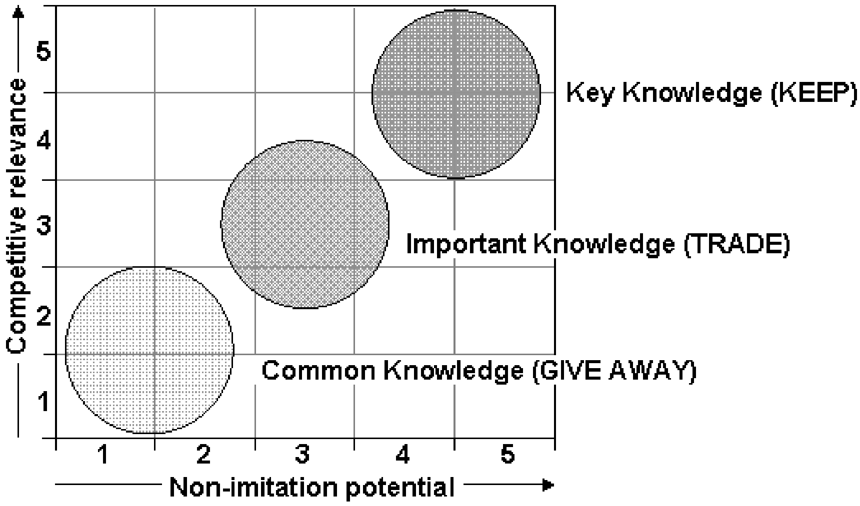
In practice knowledge management depends crucially upon interpersonal and social aspects, rather than technological and procedural mechanisms. Nevertheless, given the constraints of geographical and organisational dispersion in virtual project environments, clearly defined guidelines and an adequate IT/CT support is essential. Research findings indicated that explicit knowledge is often outdated or just inappropriate (e.g. based on a different context) and the distribution of people results in a distribution of tacit knowledge as well. Thus, technology should be able to provide a central access to formal project documents and codified knowledge as well as to offer a portfolio of tools to allow person-to-person communication. For example, a project portal may include some sort of *Yellow Pages*, presenting searchable team member profiles including competences, skills and knowledge domains. Reflecting on participant statements highlighting the need for a quick response in challenging project situations an *Urgent Request* mechanism can be embedded. Relevant team member requests are displayed on the start-up page of the project portal and an intelligent mapping algorithm searches user profiles or even emails traffic (anonymously) for corresponding key word matches and forwards the question appropriately. The whole process is monitored and if certain thresholds are surpassed (e.g. no feedback within 48 hours), escalation emails are automatically generated.

An *Instant Messaging* tool might offer alternative means to establish social connectivity even in global virtual work settings. Based on research findings, the implemented technology must provide the necessary situational flexibility to allow team members the selection of adequate synchronous or more asynchronous communication channels. One important drawback of many technological solutions is an inefficient search functionality, thus knowledge objects are 'dumped' into an IT system without ensuring the necessary categorisation and provision of contextual information. Ideally, the technological platform provides a *Meta Search* engine, founded on a joint classification scheme (Taxonomy) and a project-related agreement on the terminology / meaning for communication and action (Ontology). Several participant statements focused on unproductive and inappropriate telephone conferences; hence it has to be ensured that the necessary moderation skills, preferable in combination with a good portion of socio-cultural empathy, are [in persona] available within the team. The strategic implementation of *Knowledge Brokers* supports access to specific formal or informal networks and knowledge resources and a *Project Champion* might help in bridging existing [often political] boundaries and access key audience.

Control and Measurement

At the beginning of each project the necessity for cross-organisational cooperation is translated into a relational contract that broadly outlines areas of exchange and codes of conduct. On the first place and from a procedural point of view knowledge management has to ensure that team members get those resources necessary to fulfil the project tasks – no more, no less. But despite project focused contracts and procedures, members can use the shared knowledge in adjacent business opportunities beyond their initial agreement. Thus, it is not sufficient to protect documented knowledge using IT-related access rights, because social relationships represent a good possibility to absorb knowledge in excess of formal agreed-upon boundaries. Thus, the involved project partners have to take care that 'their' team members have a sufficient awareness regarding important and critical knowledge assets. Based on a knowledge audit (knowledge map), relevant knowledge assets can be analysed and categorised focusing on their competitive relevance and replication capabilities (see Figure 7-6). Assets are clustered in three different groups, hence key knowledge, important knowledge and common knowledge.

Figure 7-6: Knowledge analysis and assessment matrix



Source: Developed for this research

On the other side, it has to be clearly defined what exactly new collective knowledge is, how it is codified, stored and, finally, who owns it. Based on the saying “You have to be able to measure, what you want to manage”, the efficiency of project-related knowledge management has to be evaluated regularly. One approach is the compilation and analysis of usage statistics focusing on IT tools, e.g. how often have particular knowledge objects been accessed or how may new objects have been created during a given time period. This approach can be backed by SNA to investigate and judge informal collaboration activities and the exchange of more tacit forms of knowledge.

Reflection and learning

This study showed that collective reflection is an important, but often neglected, aspect of knowledge sharing and learning in virtual projects. Authors like Senge (1990) advocated that simply concentrating on fixing problems with quick solutions is insufficient; instead generative learning has to be fostered by constantly evaluating the ways in which solutions are created. In order to identify and document relevant experiences during and particularly after working on an inter-organisational project regular reflection and learning meetings should be established. Referring to the lifecycles pictured in Figure 7-3, reflection can occur on an individual as well as team level. Because the egocentric type happens constantly, but more or less unconsciously, the process should be ‘externalised’ to a certain degree and team members have to develop an awareness focusing on the link between their work and the generation of new knowledge. In this context, common training can not only strengthen methodical, social and communicative competencies, but also supports cooperative working and the development of a common project language. Moderated Lessons Learned workshops can be implemented to identify, synthesise, codify and/or share relevant knowledge assets.

In most short-term projects necessary basic conditions for knowledge exchange are missing; e.g. common understanding and language as well as a high inter-organisational and interpersonal trust. Hence, in such a context the main function of a knowledge-oriented management is the reduction of conflicts focusing on different expectations of project participants and existing knowledge asymmetries. Based on research findings and reflecting on Fong (2005b), the most widely observed strategy in inter-project learning targets tacit resources, thus team members engaged in multiple projects, rather than codification in any format. Therefore on one hand, job-rotation of team members can foster cross-project and company-wide learning and can keep the 'off-site' workforce connected with the organisation. On the other hand, if knowledge is viewed as distributed, collective and context sensitive, it might be advisable in knowledge-intensive projects to keep a core group of team members together. Focusing on project complexity, the research showed that with increasing complexity the use of informal mechanisms such as face-to-face meetings and gatherings of project managers acting as arenas for knowledge sharing and problem solving becomes more and more important. Having discussed identified implications for management practice, the next section will describe limitations of this research.

7.7 Limitations of the research

To cope with the challenging area of research (dynamic socio-cultural processes within a virtual environment), weaknesses of the case study methodology and specific data collection procedures, the inductive theory-building case study methodology has been supplemented by an embedded quantitative methodology (Social Network Analysis). In addition, two other supportive techniques have been used during refinement (convergent interviews) and analysis phase (Hypermedia-based discourse / argumentation ontology). Issues focusing on the *case study methodology* that may have a potential distorting influence on the derived assessment were the following:

Selection of interviewees

Great care has been taken to select the proper team members to interview (see chapter 4.6.1), for it is obvious that the selection of the interviewees influences the findings of the case study. Nevertheless single interviewees revealed an understanding for knowledge sharing in general, but lacked a thorough overview of knowledge sharing related issues with respect to the investigated virtual project. In these special cases, additional interviews have been carried out and supplemental evidence e.g. documents and protocols collected.

Quality of data

The interviewees were open, frank, and critical about the discussed knowledge sharing aspects in their project. Generally, they showed a good overview of these developments and were able to reflect on this. It has deliberately been tried to avoid interviewer bias or contamination, hence all in all the quality and reliability of the information that was brought forward in the case interviews can be regarded as satisfactory.

Consistency of data

Some discrepancies between the views given by different interviewees could be identified. Certainly, these views have been biased by personal characteristics, whether people are comfortable with their particular project role, their work and their colleagues at the time of the interview. Because neither other qualitative nor quantitative sources revealed any profound contradictions, this can be considered as a natural and human phenomenon.

Referring to Cross and Parker (2004), issues that may have a distorting influence on the derived findings focusing on *Social Network Analysis* are the following:

Limited network information and misinterpretation

Team members may have forgotten important relationships when they hurried to complete the SNA survey and may have inflated their responses to look themselves more central or active. Each of the constructed graphs reflected only one aspect of the sharing relationship and interpreting this network information is also much art as science; thus there is a difference between being able to take an X ray and being able to interpret it. SNA diagrams and calculated indices are compelling sense-making devices (see chapter 6.2) and care has be taken not to let beliefs and wishes take over. It was important not to get caught up in the seeming precision of the graphs and measures until conclusion have been checked with members of the investigated virtual project.

Small teams and participant dropouts

Based on the statistical character of SNA and given the comparatively small team sizes investigated (see Table 4-6) it has to be said that no adequate reference data was available to validate the results. Nevertheless, the cross-case assessment of SNA findings (see chapter 6.3 and appendix Q) showed clear and significant patterns, which might represent good starting points for further research activities. In addition, politically influenced participant dropouts in one case (see chapter 6.2.1) reduced the data basis for this particular project setting, but triangulation has been used to ensure the necessary analytical quality.

Defensiveness

SNA findings can be highly revealing, thus there is always the chance that results can evoke defensiveness in and denials from team members or project partners that are cast in a less than favourable light. Therefore case interviews have been conducted before the SNA survey to reveal the socio-political climate and all team member names have been disclosed. In addition, care has been taken to focus on the system e.g. formal or informal forces rather than on individuals to foster productive conversations.

Ethical considerations

SNA findings, as explained earlier, are highly nuanced and a team member's network position must not be the sole determinant of his or her project-related sharing performance. However, the danger exists that results can be used for destructive purposes by those with a political agenda. Thus, it was made sure that network information was used ethically and productively for all involved parties.

In summary, potential limitations of the multi-method research approach have been systematically identified and appropriate strategic responses defined (see Table 4-11). This effective synthesis of the described methods increased the robustness of results and strengthened findings though cross-validation. The mentioned limitations are acknowledged but they do not detract from the significance of presented findings, but merely provide platforms for future research, which will be elaborated further in section

7.9. The next section will reflect on successful and more difficult aspects of the implemented methodology.

7.8 Implications for methodology

New and innovative research approaches always represent a good learning environment; therefore corresponding implications and 'lessons learned' will be addressed next.

After the literature review *convergent interviewing* has been used as stage one of the three-stage data collection process and proved its suitability as useful tool to further develop and refine the research problem. The tool supported the discovery of new dimensions and aspects focusing on knowledge management in virtual project settings. This in turn helped with the identification of appropriate research issues as well with the design of new questions needed to test those new issues. The implemented case study methodology build on *depth-interviews* whose content and structure was designed based on the research question and the five identified research issues. Despite the fact that the overall data collection process was piloted, later case interviews showed that some equivocal questions have not been detected. Hence, related experience suggested that five instead of two pilot interviews should enhance the quality sufficiently. Focusing on case interviews it appeared that for presumably busy team members the interview length should be kept between 30 and 40 minutes, whereas more passionate individuals are willing to spend 50 minutes and more. In this context and referring to the interview analysis, it became evident that the number of open questions could be reduced by 20 per cent without risking data and result quality. Instead it should be tried to collect a portfolio of project-related anecdotes and stories, because theses artefacts represent a very effective way of establishing the necessary contextual understanding for the interpretation of case-related results and findings. Finally it should be noted that summary questions and their statistical analysis helped a lot to get a grip on sometimes foggy and opaque interviewee statements.

Focusing on *Social Network Analysis (SNA)* as the third quantitative stage of the data collection process no prior experience existed regarding its application in this particular research context. Consequently, design-related guidelines were missing and adequate baseline data as 'benchmarking repository' was not available. Hence the research started with a broad spectrum of measures and indices to test their suitability and relevance, which in turn increased complexity and the amount of data to be handled, structured and investigated. It has to be said that, despite the availability of comprehensive tools like IKNOW (2003) or UCINET (2004) which produce nice and visually compelling results, SNA is a complex and challenging matter. Especially the case-related interpretation of SNA results and cross-method synthesis with qualitative data findings proved to be a challenging endeavour. In this context, the support of experienced SNA practitioners and researchers helped a lot to ensure the necessary quality of the explanatory stage of this research.

The software tool Compendium (2005) has been chosen to support the final analytic phase and allowed the *visualisation, navigation and analysis of the composed network of multi-method research findings*. It comprises a methodology which offers the functionality to map key issues, possible responses to these, and relevant arguments. Although the generated maps were very compelling (see Figure 7-1) it has to be said that the necessary data input and data manipulation was, based on the amount of findings, very time consuming. Thus in essence, this software should be either used in collaborative and distributed research settings (multi user environment) to develop a mutual discourse / argumentation ontology or in cases where all results and findings could be stored, structured and assessed in one central and standardised database. Having discussed the implications and related experiences based on the application of the developed methodological approach, directions for future research will be addressed next.

7.9 Directions for future research

Given the nature of the research question and the number of investigated research issues as well as the comprehensive research methodology applied, several suggestions for further research could be identified during this study:

- *Replication* of this study is needed to further substantiate the findings and conclusions of this research. The inclusion of other industries besides the five involved ones and increasing the number of team members will help to generalise the findings further.

- The used multi-method research design can be streamlined and further developed into an *efficient diagnosis and assessment tool*, which could be piloted and tested using two to three virtual project settings. Especially the synthesis of qualitative and quantitative results e.g. using a hypermedia-based ontology as well as the subsequent reasoning process could be optimised.

- Application of the research methodology within *organisational team environments* could provide supplemental insights focusing on differences in organisational vs. project-based Knowledge Management.

- Future research could investigate the integration of the developed conceptual framework in *common project management models* in particular targeting the situational balance between explicit ‘top-down’ training and more ‘bottom-up’ tacit learning approaches.

- Given the importance of the *concepts of ‘Openness’ and ‘Trust’* with respect to communication in general and knowledge sharing in particular, a focused research approach could enhance the related understanding, help to refine extant strategies as well as policies.

- The SNA-related QAP-Correlation analysis could be expanded to from a single focus on information / knowledge sharing to an *investigation of cross-variable relationships* between all SNA variables e.g. what is the influence of ‘Proximity’ on the construction of mental knowledge maps, thus SNA variable ‘Knowing’ or how does the length of team membership (SNA variable ‘Tenure’) impacts the access to knowledge resources.

- Investigating the aspects of *taxonomy and ontology* regarding collective context-building in virtual project environments might not only support the effective organisation of knowledge resources, but also their timely retrieval and task-specific recombination.

- From a business perspective one of the biggest challenges is *to link knowledge management with economic results*. Thus, many initiatives fail or even don’t get initiated, because a convincing cost-benefit calculation could not be provided. Research on the SNA-enabled development of an appropriate argumentation framework and related indices might help Chief Knowledge Officers and project managers to get the audience and resources they need.

In summary and given the dynamic and interconnected socio-cultural aspects investigated, this theory-building research showed that knowledge management in virtual environments is more complex than common business practice suggests. Due to their temporary nature, projects do not possess any organisational memory. In contrast with organisations, which are supported by structure, routines and a comparably stable workforce to absorb knowledge, virtual projects miss any natural transfer mechanism. The research showed that that many teams [and the involved parent organisations] tend to look at virtual project teams and related knowledge management through the filters of the old thus keeping the old models and old language in place. The majority of knowledge management frameworks, policies and processes have been planed and implemented with a sole fixation on the legal, formal project organisation. The nature of relevant knowledge objects, thus either tacit or explicit, and their transferability were not taken into account sufficiently. Nevertheless, projects are guided by the constraints of time, budget and quality, which make the reuse and harnessing of knowledge a necessity. But organisations often launch new initiatives without understanding the inner working of involved formal and informal networks, relying on the philosophy that more communication and collaboration are better. Apart from an economic / financial point of view, the ‘target audience’ often gets overwhelmed by a tidal wave of information and requests and productivity deteriorates. Reflecting on Liebowitz (1999) the goal is to use Knowledge Management in virtual project environments to ‘work smarter, not harder’, thus stimulate knowledge sharing, improve team member productivity and fulfilment and finally increase customer / stakeholder satisfaction.

8 GLOSSARY

Ø:	Average or mean
COP:	Community of practice
CT:	Communication Technology
F2F:	Face-to-Face
GPM:	German Association for Project Management
IKNOW:	Inquiring Knowledge Networks On the Web
IPMA:	International Project Management Association
IT:	Information Technology
KIN:	Knowledge Integrator Node
KM:	Knowledge Management
LCOF:	Life Cycle Objective functions
LCPM:	Life Cycle Project Management
NGO:	Non-governmental organisation
PLC:	Project Life Cycle
PM:	Project Management
PMI:	Project Management Institute
QAP:	Quadratic Assignment Procedure
RI:	Research Issues
SME:	Small and Medium Enterprise
SNA:	Social Network Analysis
VPT:	Virtual Project Teams

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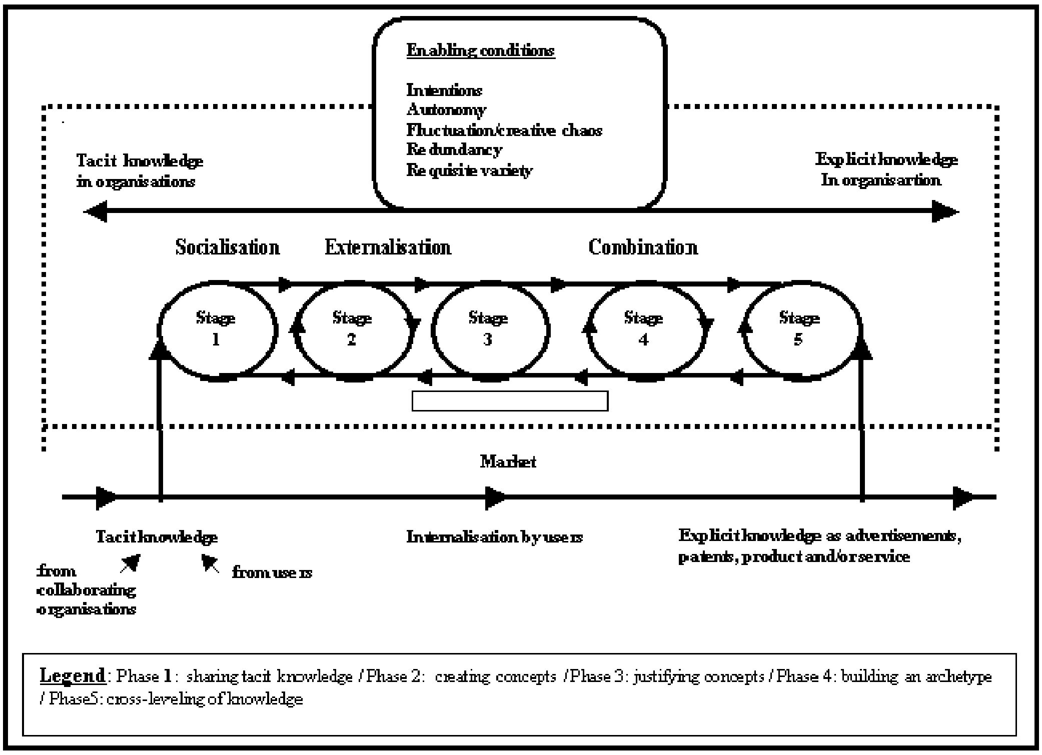
10 APPENDICES

10.1 Appendix A: Five phase model of knowledge-creation



Source: Erwee et al. 2000

10.2 Appendix B: Convergent Interviews - Structure and content

Introduction

Short personal introduction

Mention approx. interview time and check with interviewee !!!

Explain the purpose of the interview

Uses to be made of the collected data

Ensure anonymity and confidentiality

Amount of access that respondents will have to the data and interpretations

Interviewee information:

- *Which industry?*
- *How many employees?*
- *What hierarchical level and what function?*

> Ask respondent if he/she has any questions about the purpose or conduct of the interview before commencing.

General Questions

Start-up Question:

- *"Please tell me the story of your experience of [knowledge management in the context of] virtual project teams"*

Probe Questions

a) In your opinion - is the organisational utilisation of virtual project environments increasing or not?
b) How do you personally judge the effectiveness of virtual project teams as organisational form?

(continued)

c) Have you experienced situations where knowledge was lost in virtual project settings, e.g. to external partners?
d) To what extent was knowledge lost? *(Question removed)*
e) How is the loss of knowledge judged within the [project] organisation?
f) What actions have been implemented to prevent the loss of knowledge and to strengthen the own organisation?
g) Are there dedicated knowledge processes in place regarding virtual project teams and corresponding project frameworks or methodologies?
h) What actions have been implemented to convert tacit knowledge into explicit knowledge?
i) How is explicit knowledge systematically collected, stored and distributed?
j) What actions have been implemented to measure the relevant knowledge?

Conclusion

Sum up of relevant agreements or disagreements

- *"Of all the things you've mentioned, which five or six do you think are most [or less] important?" …" Of those six items, which is most [or less] important? Which is next most [or less] important"*

Who else in your organisation should I talk to?

> Ask the respondent if he/she has any question about the interview

> Assure the respondent that the information from the interview will remain anonymous and confidential

> Thank the respondent for taking part

10.3 Appendix C: Convergent interviews – Significant respondent statements

Category	Important respondent statements
Benefits	• Virtual team settings are often handled more professional than traditional organisational forms • Better work live balance > New flexibility • High employee fluctuation > Increased failure rate > "Capitalise" collected knowledge • VPT's helped to reduce the overall product development project duration for approx. 45%
Communication	• Disciplined communication > higher efficiency • Message clarity and precise formulation important • Abstraction level > Communication differences between novices and experienced people • Language barrier fosters the loss of knowledge • Common understanding and vocabulary necessary • Language proficiency is important • Clear and unmistakably formulation of knowledge is important • Code of ethic and dedicated communication rules
Network	• Virtual project team > development / evolution > community of practice • Disagreement: Value of communities questionable > more focus on processes in the future • Best practice: An appropriate project was "coated" or "wrapped" with an corresponding community • Keep the experts (knowledge) after the project together and accessible • Disagreements: Communities are as individual as single people are > There is no "ideal" community
Processes	• Traditional methodology's/processes have to be adapted • Disagreement: Too much emphasis on getting tacit knowledge out of people / People cannot be forced to share their wisdom • Shift from "troubleshooting mentality" towards a more process-focused culture • Conversion of tacit into explicit knowledge via appropriate QS processes • The effective use of appropriate applications and agreed upon rules in VPT is often missing in traditional project setting • A loss of knowledge is built into the [every] process
Risks	• Daily business is too stressful • Internal competition > individuals career paths > mistrust • Strong intervention by unions regarding the electronic storage of employee skills • Head-hunter & skill databases > Loss of relevant knowledge > Bad experiences • External consultants = external knowledge > no systematic knowledge transfer took place > knowledge was lost • Problems with workers association • Wrong knowledge might kept alive and used by project team members • More loss of knowledge in traditional teams > No tools, no appropriate processes and only poor discipline
Social / Cultural	• Development of trust not necessarily through personal contact, but collaborative tools • Regular personal contact is important > Trust / Team building / Project success
Structure	• Collaboration needs an homogeneous team structure • Focus on "Problem/Solution" framework • SME managers get a much faster and clearer feedback on their decisions than managers in big, global organisations > faster development is fostered > taking risks is more encouraged
Tools / Technologies	• Global focus > low internet bandwidth > insufficient tool performance • Disagreement: Electronic Communities and a [too much] tool-focused business approach > Low tech is sufficient • Tool performance and user friendliness was (is) more important than nice state-of-the-art visual appearance • The effective use of appropriate tools and common processes [available in VPT's] is often missing in traditional project setting
Training / Experience	• Training and experience (social & technological) is necessary • Train the knowledge documentation process > Show team members how to do it > Proof how easy and useful it is

Source: field data

10.4 Appendix D: Case study interview protocol

Remark: The overall structure of the interview protocol is based on Healy (2000), whereas specific content has been developed from studies conducted by Rubenstein-Montano et al. (2001), Herzog (2001) as well as Pearce et al. (1992).

Interview related data

Case number: …

Interview number: …

Date: …

Interviewee's name: …

Interviewee's team role: …

Interviewee's parent group / organisation: …

Interviewee's location of work: …

Start time: …

End time: …

PART A: Introduction

Thank you for your cooperation. This research would not be possible without your participation. The benefits of this research are new conceptual approaches and practical implications focusing on knowledge management in virtual project environments.

Purpose of this research

To investigate the socio-cultural enabling conditions and network-related processes which support the optimal knowledge creation and exchange in virtual project teams.

Status of this research

This research is doctoral research conducted at the Faculty of Business / University of Southern Queensland / Australia. If confirmation is required you may contact Professor Ronel Erwee, Director Faculty of Business, on +61 7 4631 1173.

Ethical concerns of this research

- This research is confidential. You, the project and your parent organisation will not be identified in the report. Even incidental identification of the project and your firm will not be possible, as steps will be taken to disguise all participants.
- Undisguised information about participants in this research will not be made public nor given to a third party

(continued)

Notes

- Would you mind if I record the interview as it will help with the data analysis? We can stop the recording at any point throughout the interview.
- Are there any further questions either about the interview procedure or the purpose of the research?
- If you wish I would be very happy to provide you with a summary of the results.

PART B: Opening questions

I will begin by asking you some broad questions about you and your function/role in the virtual project team:

- (B1) Would you please tell me the story of your experiences regarding virtual project teams and the ways knowledge is generated and shared?
- (B2) Could you please tell me about your responsibilities and activities within the project team?

Related Likert-style questions:

- (B3) I am familiar with "knowledge management" as a term and concept.
- (B4) This project team has the leadership capability to succeed in knowledge management.
- (B5) What is intangible in projects or organisations is hardly worth measuring.
- (B6) Does your (parent) organisation's overall strategic goals include knowledge management explicitly?

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART C: Type and level of trust

Probe questions:

- (C1) How is trust established in this particular virtual project team?
- (C2) Can you identify and describe different types and levels of trust in your virtual project team?

Summary questions:

- (C3) Members of this virtual project team show a great deal of integrity.
- (C4) I can rely on those with whom I work in this project team.
- (C5) Trust is the primary facilitator focusing in knowledge management in virtual project teams.
- (C6) The enhancement of trust does not happen on its own, but depends on a well managed approach.
- (C7) We are usually considerate of one another's feelings in this project team.
- (C8) There is no "team spirit" in this project team.

(continued)

- (C9) Team member reliability, consistency, and responsiveness enhances the level of trust.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART D: Shared language and common vocabulary ________________________________

Probe questions:

- (D1) Have you experienced communication problems based on a different vocabulary or language?
- (D2) Have you experienced difficulties in (sharing and) applying other parties knowledge?

Summary questions:

- (D3) Communications are poor.
- (D4) In this virtual project team we share a common language – technically as well as personally.
- (D5) Communications are primarily formal.
- (D6) Open and honest communications support knowledge generation and sharing.
- (D7) Sometimes documented knowledge isn't easy to understand.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART E: Face-to-face interaction ____

Probe questions:

- (E1) How often do you meet team members you are working with?
- (E2) How does the reduced personal contact with other team members influence your work as well as the generation and sharing of knowledge?

Summary questions:

- (E3) Trust can be build virtually, thus no face-to-face contact is necessary.
- (E4) Regarding complex issues I definitely prefer a direct face-to-face communication instead of virtual communication channels.
- (E5) Knowledge can be best shared in close personal contact with other team members.
- (E6) This project would run smoother (and better project results could be realised) if more face-to-face interaction would be possible.
- (E7) Knowledge can't be stored in data bases.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART F: Influence of informal networks ____

Probe questions:

(continued)

- (F1) Can you identify informal networks or groups within this virtual project team?
- (F2) How would you rate the importance of informal networks or groups regarding the generation and sharing of knowledge?

Summary questions:

- (F3) It is not possible for an individual team member to sufficiently identify informal networks.
- (F4) Informal contacts are much more suitable for effective knowledge sharing than formal ones.
- (F5) Informal networks or groups are the primary driving force in virtual project teams.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART G: Risks associated with knowledge transfer ________________________________

Probe questions:

- (G1) Which aspects of your organisational / your partners culture seem to provide barriers to effective knowledge management?
- (G2) Organisations or partners cooperate and compete in virtual project-based settings. How does this project team and the involved organisations ensure control of unique knowledge?
- (G3) Are you aware of knowledge losses in the context of this project team?

Summary questions:

- (G4) The collaborative partner’s corporate culture isn't as open as ours (or vice versa).
- (G5) Knowledge is always lost in virtual project teams.
- (G6) The collaborative partners certainly have a lot more experience than we do in certain areas.
- (G7) The project has established clear and efficient procedures to protect each parties knowledge sources.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART H: Team member characters / Individual skills ______________________________

Probe questions:

- (H1) On what basis, e.g. technical skills, interpersonal skills or hierarchical position, have individuals been chosen for this project team?
- (H2) Do you think that additional (e.g. socio-cultural and technical) skills are necessary to be a good performer in a virtual project environment regarding knowledge generation and sharing?
- (H3) Are there special team member characters that are best suited for virtual project work and related knowledge generation and sharing?

Summary questions:

(continued)

- (H4) My work primarily involves completing independent tasks.
- (H5) I'm going to learn a lot by being on this project.
- (H6) No additional skills are needed in virtual project environments.
- (H7) People are on this team because they are competent.
- (H8) There are clear character-related team member attributes that supports virtual project work.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

PART I: Additional questions

Probe questions:

- (I1) How much time do you spend looking for knowledge (out of a 40-hr. week)?

Related Likert-style questions:

- (I2) All in all, I am satisfied with virtual project work.
- (I3) Since I started working virtually, I have been able to balance my job and personal life.
- (I4) Since I started working virtually, my productivity has increased.

Five-point scale: 1 = Strongly disagree, 5 = Strongly agree, 0 = n/a

- (I5) Are there any other points you would like to make or areas that we have not mentioned that would help me understand your situation with regard to knowledge management?
- (I6) If I need to clarify any points, do you mind if I contact you again?

Your contribution to this research is greatly appreciated

Thank you

10.5 Appendix E: SNA questionnaire

Remark: The relational attributes (variables) of the questionnaire have been developed from Borgatti & Cross (2003).

Collected individual and demographic data: (1) Name, (2) Parent group or organisation, (3) Person's role / function in the project team, (4) tenure within the group (in months) and (5) physical location.

Attribute name	**Question**
1a./1b. Information (I)	(GetInfo) Please indicate how often you have turned to this person for information or knowledge on work-related topics in the past 3 months. 1 = Never, 5 = Very frequently, 0 = I do not know this person. (GiveInfo) Please indicate how often this person has turned to you for information or knowledge on work-related topics in the past 3 months. 1 = Never, 5 = Very frequently, 0 = I do not know this person.
2. Contact (T)	How often do you communicate by whatever method (e-mail, phone, face-to-face etc) with each person in the group. 0=Not at all, 1=Less than once a month, 2=Once a month, 3= Once a week, 4= Twice a week, 5= Daily, 6= Several times a day.
3. Knowing (K)	I understand this person's knowledge and skills. This does not necessarily mean that I have these skills or am knowledgeable in these domains, but that I understand what skills this person has and domains they are knowledgeable in. 1 = Strongly disagree, 5 = Strongly agree, 0 = I do not know this person.
4. Value (V)	This person has expertise in areas that are important in the kind of work I do. 1 = Strongly disagree, 5 = Strongly agree, 0 = I do not know this person.
5. Access (A)	One issue in getting information or advice from others is your ability to gain access to their thinking. The extent to which you can access another person's thinking and knowledge is a continuum. At one end of the spectrum are people who do not make themselves available to you quickly enough to help solve your problem. At the other end of the spectrum are those who are willing to engage actively in problem solving with you in a timely fashion. With this continuum in mind, how would you rate your overall ability to access this person's thinking and knowledge? 1 = Extremely weak, 5 = Extremely strong, 0 = I do not know this person.
6. Cost (C)	Seeking information or advice from other people can be costly. For example, with some people you may not feel comfortable revealing your own lack of knowledge on a given topic. Alternatively, people you ask for information may make you feel excessively indebted to them. In light of such interpersonal risks and obligations, please indicate the extent to which you feel that seeking information or advice from this person is costly. 1 = Very costly, 5 = Not at all costly, 0 = I do not know this person.

10.6 Appendix F: Web-based Social Network Analysis tool (IKNOW)

IKNOW (Inquiring Knowledge Networks On the Web), is a web application developed by the University of Illinois to study the co-evolution of knowledge and information networks (IKNOW 2003). IKNOW helps an organisation by putting in place a mapping, visualisation, and measurement system that can help organisations to study the patterns of knowledge and information flow though an organisations informal network. This, in turn, can help enhance an organisation's capability to identify critical patterns of knowledge distribution and information flow, and thus, more effectively manage these knowledge assets. IKNOW provides the focus associated with mapping, measurement and visualisation of knowledge networks and combines it with the power of structured collaboration. Further its ability to run on many popular Web platforms enhances its ease of use.

In short, IKNOW will answer the following (IKNOW 2003):

- Who knows who?
- Who knows what?
- Who knows who knows who?
- Who knows who knows what?

Ease of collecting and producing data for analysis. Remote data collection using a browser interface that can be used to dynamically analyse data as soon as it is entered. In addition, customisation of the application can also be done remotely through a browser interface.

Ease of use for data analysis. Data can be analysed using most modern browsers from any computer connected to the server, including through an internet connection. Analysis of the data is also directly related to how the application has been customised.

Documentation Provided. I-KNOW comes with minimal documentation in terms of a brief user guide and guide for installation.

Technical / Hardware Requirements. Requires its own web server (Apache is included as part of the distribution) running NT with a connection to the internet.

Web Browser graphics. Produces information rich interactive graphs of the social / knowledge networks using a customised version of Michael Chan's Spring Embedder.

Free to use. Free for non-commercial use.

10.7 Appendix G: Social Network Analysis tool (UCINET)

UCINET is a comprehensive program for the analysis of social networks and other proximity data. A comprehensive package for the analysis of social network data as well as other 1-mode and 2-mode data. Can read and write a multitude of differently formatted text files, as well as Excel files. Can handle a maximum of 32,767 nodes (with some exceptions) although practically speaking many procedures can get slow around 5,000 - 10,000 nodes.

Social network analysis methods include centrality measures, subgroup identification, role analysis, elementary graph theory, and permutation-based statistical analysis as well as

- dyadic cohesion measures,
- positional analysis algorithms,
- clique finders,
- stochastic dyad models (P1),
- network hypothesis testing procedures (including QAP matrix correlation/regression and categorical and continuous attribute autocorrelation tests),
- general statistical and multi-variate analysis tools such as multi-dimensional scaling, correspondence analysis, factor analysis, cluster analysis, multiple regression.

In addition, UCINET provides a host of data management and transformation tools ranging from graph-theoretic procedures to a full-featured matrix algebra language. Integrated with UCINET is the NetDraw program for drawing diagrams of social networks.

10.8 Appendix H: Case study participation email

To: [Potential research participant]

Title: Participation in an international research study focusing on Knowledge Management in virtual project environments

Dear [Participant],

As a doctoral student of the Faculty of Business, University of Southern Queensland / Australia, I am undertaking research on knowledge management in virtual project teams. I am sending you this email to request your organisations participation in an international research on knowledge management in virtual project teams. This research is important because it will help both organisations like yours and other researchers to understand better how valuable knowledge is created, identified and shared in virtual project-based work environments.

A multi-method approach utilising telephone-based depth interviews and web-based Social Network Analysis (SNA) will be used in this study. The overall expenditure with regard to time for the entire participating virtual project team will be about 6 hours usually distributed over a period of two weeks. I understand that the individual team members time is at premium and in return for the appropriate efforts, I would be very happy to provide you with a summary of the case-based findings, thus 'your' particular project team, as well as with the final research report.

Please be assured that all collected data will be treated with strict confidentiality. The interview protocols as well as the questionnaires will be handled on an anonymous basis and the results will be reported for the entire study rather than on an individual basis. You may withdraw from the study at any time.

If you have any queries or require further clarification regarding the conducted research, please do not hesitate to contact me by email or telephone under +49 172 240 25 25.

Yours Sincerely,

Frank D. Behrend

****
Am Tiefenberg 14
40629 Duesseldorf
Germany
Mobile: + 49 172 / 240 25 25
Email: mail@FrankDBehrend.de
****

10.9 Appendix I: Introductory email (SNA Questionnaire)

To: [SNA survey respondent]

Title: Your participation in the survey focusing on Knowledge Management in virtual project environments

Dear [Respondent],

As a doctoral student of the Faculty of Business, University of Southern Queensland / Australia, I am undertaking research on knowledge management in virtual project teams. There is only limited empirical research from a knowledge perspective of managing multi-location project teams whose work is highly complex and dynamic in nature and a membership mix of internally employed personnel as well as external partners and/or other contract "staff". This research is important because it will help both practitioners as yourself and other researchers, understand better how valuable knowledge is created, identified and shared in virtual project-based work environments.

The web-based questionnaire consists of seven questions and should take approximately 10-15 minutes to complete. You can access the questionnaire via [Internet link] using the password “[password]”. Please complete the contact information screen first before proceeding with the main part of the survey. Your responses will remain completely confidential. For analysis and reporting purposes your anonymous responses will be combined with those from other investigated project teams.

Please answer all questions on the survey. If you have any queries or require further clarification regarding the survey, please do not hesitate to contact me by email or telephone under [telephone number]. If you would like to receive a summary of the main findings of the research, please send me an email or call.

I would like to take this opportunity to express my appreciation for your cooperation in completing the survey by [due date], and to thank you for your valuable assistance with this research.

Yours Sincerely,

Frank D. Behrend

****

Am Tiefenberg 14

40629 Duesseldorf

Germany

Mobile: + 49 172 / 240 25 25

Email: mail@FrankDBehrend.de

****

10.10 Appendix J: Informed Consent Form

Dear [Participant],

As a doctoral student of the Faculty of Business, University of Southern Queensland / Australia, I am undertaking research on knowledge management in virtual project teams. There is only limited empirical research from a knowledge perspective of managing multi-location project teams whose work is highly complex and dynamic in nature and a membership mix of internally employed personnel as well as external partners and/or other contract "staff". This research is important because it will help both practitioners as yourself and other researchers, understand better how valuable knowledge is created, identified and shared in virtual project-based work environments.

A multi-method approach utilising telephone-based in-depth interviews and a survey-based Social Network Analysis (SNA) will be used in this study. Focusing on qualitative data collection, in-depth interviews with 3 relevant representatives will be carried out. To visualise informal networks within each virtual project team and to acquire additional quantitative data focusing on information / knowledge structures and processes, a web-based survey will be used to conduct a case-related Social Network Analysis (SNA). The time needed for each team member will be approx. 10 minutes.

Please be assured that all collected data will be treated with strict confidentiality. The interview protocols as well as the questionnaires will be handled on an anonymous basis and the results will be reported for the entire study rather than on an individual basis. You may withdraw from the study at any time.

If you have any queries or require further clarification regarding the research and your participation, please do not hesitate to contact me by email (mail@FrankDBehrend.de) or telephone under +49 172 240 25 25. If you would like to receive a summary of the main findings of the research, please send me an email or call.

***

I consent to participate in this research project with the knowledge that I can cease participation at any time for any reason and withdraw any data previously supplied.

.......……………………..……....   .....…………………….

Signature   Date

10.11 Appendix K: Overview case participants and interview partners

No.	ID	Type	Case	Gender	Tenure [Months]	Location	Organisation	Profile
1	n/a	Convergent Interview	N/a	M	N/a	Luxemburg	Astra Satellites	Project Manager and Lecturer
2	n/a	Convergent Interview	N/a	M	N/a	Germany	Independent Consultant	IPMA President and Project Manager
3	n/a	Convergent Interview	N/a	M	N/a	Germany	IBM	Manager
4	n/a	Convergent Interview	N/a	M	N/a	Great Britain	Independent Consultant	IPMA President and Lecturer
5	n/a	Convergent Interview	N/a	M	N/a	Germany	Braiconn	Market Researcher and Analyst
6	n/a	Convergent Interview	N/a	M	N/a	Germany	Infineon	Project Manager
7	n/a	Convergent Interview	N/a	M	N/a	India	Independent Consultant	Lecturer and IPMA President
8	n/a	Convergent Interview	N/a	M	N/a	Germany	Otis Elevators	Director Human Resources Programs
9	n/a	Convergent Interview	N/a	F	N/a	Switzerland	Ifi GmbH	Organisational Psychology Researcher
10	n/a	Convergent Interview	N/a	M	N/a	France	Valeo	Branch Project Director
11	n/a	Convergent Interview	N/a	M	N/a	Germany	Siemens	Internal Consultant and Project Manager
12	n/a	Convergent Interview	N/a	M	N/a	Germany	Siemens	Business Process Executive
13	n/a	Informative Interview	N/a	M	N/a	Australia	IBM	KM Consultant
14	n/a	Informative Interview	N/a	M	N/a	Germany	ThyssenKrupp	Chief Knowledge Officer
15	n/a	Informative Interview	N/a	M	N/a	Germany	PwC Deutsche Revision	KM Consultant
16	n/a	Informative Interview	N/a	M	N/a	USA	The St. Paul Companies	Assistant Vice President KM
17	n/a	Informative Interview	N/a	M	N/a	Germany	Gerling	PE/Q New Media
18	n/a	Informative Interview	N/a	M	N/a	Germany	Henkel KGaA	Chief Knowledge Officer
19	P08	Depth-Interview	Pilot Study	M	30	Germany (City 1a)	IT Service Company	Technical Consultant & Developer
20	P03	Depth-Interview	Pilot Study	M	36	Germany (City 1a)	IT Service Company	Technical Consultant & Administrator
21	P04	SNA Survey	Pilot Study	M	36	Germany (City 1a)	IT Service Company	Project Manager & Managing Director
22	P03	SNA Survey	Pilot Study	M	36	Germany (City 1a)	IT Service Company	Technical Consultant & Administrator
23	P08	SNA Survey	Pilot Study	M	30	Germany (City 1a)	IT Service Company	Technical Consultant & Developer
24	P05	SNA Survey	Pilot Study	F	36	Germany (City 1b)	IT Service Company	Training Coordinator
25	P06	SNA Survey	Pilot Study	M	30	Germany (City 1a)	IT Service Company	Project Coordinator & Developer
26	P02	SNA Survey	Pilot Study	M	36	Germany (City 2)	Client	Project Leader (Client)
27	P03	SNA Survey	Pilot Study	M	28	Germany (City 2)	Client	Technical Coordinator & Administrator
28	A20	Depth-Interview	Case A	M	48	Germany (City 1 2 3)	IT Consulting Company	Business Analyst
29	A18	Depth-Interview	Case A	M	32	Germany (City 3)	Client B	Developer
30	A23	Depth-Interview	Case A	M	24	Germany (City 2)	Client D	Developer
31	A11	SNA Survey	Case A	M	32	Germany (City 1 2 3)	IT Consulting Company	Project Manager
32	A20	SNA Survey	Case A	M	48	Germany (City 1 2 3)	IT Consulting Company	Business Analyst
33	A18	SNA Survey	Case A	M	32	Germany (City 3)	Client B	Developer
34	A17	SNA Survey	Case A	M	44	Germany (City 2)	IT Consulting Company	Developer
35	A35	SNA Survey	Case A	M	32	Germany (City 3)	Client B	Developer
36	A23	SNA Survey	Case A	M	24	Germany (City 2)	Client D	Developer
37	A22	SNA Survey	Case A	M	32	Germany (City 1 2 3)	IT Consulting Company	Business Analyst
38	A27	SNA Survey	Case A	F	14	Germany (City 2)	Client A	Developer
39	A13	SNA Survey	Case A	M	51	Germany (City 2)	IT Consulting Company	Developer
40	A33	SNA Survey	Case A	M	50	Germany (City 2)	IT Consulting Company	Developer
41	A12	SNA Survey	Case A	M	46	Germany (City 2)	Client D	Developer
42	A19	SNA Survey	Case A	M	14	Germany (City 2)	Client A	Developer
43	A31	SNA Survey	Case A	M	51	Germany (City 2)	Client D	Developer
44	A37	SNA Survey	Case A	M	18	Germany (City 3)	Client B	Developer
45	A28	SNA Survey	Case A	M	20	Germany (City 2)	Client D	Developer
46	B15	Depth-Interview	Case B	M	118	Kenya	R&D Consortium	Principal Economist and Global coordinator
47	B16	Depth-Interview	Case B	M	120	Indonesia	R&D Consortium	Regional coordinator
48	B14	Depth-Interview	Case B	F	96	Brazil	Organisation 2	Brazil facilitator
49	B11	SNA Survey	Case B	M	10	Brazil	R&D Consortium	Regional facilitator
50	B12	SNA Survey	Case B	M	108	Indonesia	Organisation 4	Indonesia facilitator

(continued)

No.	ID	Type	Case	Gender	Tenure [Months]	Location	Organisation	Profile
51	B13	SNA Survey	Case B	M	15	Cameroon	Organisation 3	Cameroon coordinator
52	B14	SNA Survey	Case B	F	96	Brazil	Organisation 2	Brazil facilitator
53	B15	SNA Survey	Case B	M	118	Kenya	R&D Consortium	Global coordinator
54	B16	SNA Survey	Case B	M	120	Indonesia	R&D Consortium	Regional coordinator
55	B17	SNA Survey	Case B	F	24	Thailand	Organisation 1	Thailand facilitator
56	B18	SNA Survey	Case B	F	13	Kenya	R&D Consortium	Programme administrator
57	B19	SNA Survey	Case B	F	13	Kenya	R&D Consortium	Political Scientist / Programme Associate
58	B20	SNA Survey	Case B	F	14	Kenya	R&D Consortium	ASB Junior Professional Officer
59	C14	Depth-Interview	Case C	F	3	Australia (City 1)	Team Cultural Change	Facilitator
60	C12	Depth-Interview	Case C	F	4	Australia (City 2a)	Team Cultural Change	Facilitator - Cultural Change Initiative
61	C13	Depth-Interview	Case C	F	5	Australia (City 2b)	Team Cultural Change	Facilitator
62	C15	Depth-Interview	Case C	F	75	Australia (City 2b)	Team KM	Knowledge Manager
63	C11	Depth-Interview	Case C	F	5	Australia (City 2a)	Team Cultural Change	Facilitator
64	C14	SNA Survey	Case C	F	3	Australia (City 1)	Team Cultural Change	Facilitator
65	C10	SNA Survey	Case C	F	2	Australia (City 2a)	Team Cultural Change	Change Management Co-ordinator
66	C11	SNA Survey	Case C	F	5	Australia (City 2a)	Team Cultural Change	Facilitator
67	C12	SNA Survey	Case C	F	4	Australia (City 2a)	Team Cultural Change	Facilitator - Cultural Change Initiative
68	C13	SNA Survey	Case C	F	5	Australia (City 2b)	Team Cultural Change	Facilitator
69	C15	SNA Survey	Case C	F	75	Australia (City 2b)	Team KM	Knowledge Manager
70	C16	SNA Survey	Case C	F	72	Australia (City 1)	Team KM	Knowledge Manager
71	C17	SNA Survey	Case C	F	78	Australia (City 3)	Team Intranet	Intranet Manager
72	C18	SNA Survey	Case C	F	10	Australia (City 2a)	Team Intranet	Business Unit Intranet Coordinator
73	D10	Depth-Interview	Case D	M	12	Germany (City 1)	Project T	Lead System Architect
74	D13	Depth-Interview	Case D	M	2	Italy (City 1)	Project T	System Architect
75	D16	Depth-Interview	Case D	M	3	Germany (City 3)	Project E	System Architect
76	D10	SNA Survey	Case D	M	12	Germany (City 1)	Project T	Lead System Architect
77	D11	SNA Survey	Case D	M	4	Italy (City 1)	Project T	Lead System Architect
78	D12	SNA Survey	Case D	M	6	Italy (City 2)	Project T	System Architect
79	D13	SNA Survey	Case D	M	2	Italy (City 1)	Project T	System Architect
80	D14	SNA Survey	Case D	M	4	Germany (City 2)	Project B	System Architect
81	D15	SNA Survey	Case D	M	5	Switzerland (City 1)	Project E	Lead System Architect
82	D16	SNA Survey	Case D	M	3	Germany (City 3)	Project E	System Architect
83	D17	SNA Survey	Case D	M	12	Germany (City 1)	Project E	System Architect
84	D18	SNA Survey	Case D	M	12	Germany (City 1)	Project T	Sponsor
85	D19	SNA Survey	Case D	M	6	Germany (City 1)	Project E	Sponsor
86	D26	SNA Survey	Case D	M	4	Belgium	Project T	System Architect, Sponsor
87	D21	SNA Survey	Case D	M	12	Switzerland (City 2)	Project E	Lead System Architect
88	D22	SNA Survey	Case D	M	9	Netherlands	Project B	Sponsor
89	D23	SNA Survey	Case D	M	12	Great Britain	Project B	Sponsor
90	D24	SNA Survey	Case D	M	12	Germany (City 2)	Parent company	Outsourcing Solution Director
91	D25	SNA Survey	Case D	F	6	Switzerland (City 1)	Project Office	Project Coordinator
92	E12	Depth-Interview	Case E	M	52	Germany	Airline Alliance HQ	Project Manager
93	E13	Depth-Interview	Case E	M	9	Germany	Airline 1	Project Manager
94	E10	Depth-Interview	Case E	M	60	Poland	Airline 2	Project manager
95	E15	Depth-Interview	Case E	M	6	Korea	Airline 5	Product Owner
96	E10	SNA Survey	Case E	M	60	Poland	Airline 2	Project manager
97	E11	SNA Survey	Case E	M	18	Austria	Airline 3	Project business representative
98	E12	SNA Survey	Case E	M	52	Germany	Airline Alliance HQ	Project Manager
99	E13	SNA Survey	Case E	M	9	Germany	Airline 1	Project Manager

(continued)

No.	ID	Type	Case	Gender	Tenure [Months]	Location	Organisation	Profile
100	E14	SNA Survey	Case E	M	17	Japan	Airline 4	Product Owner
101	E15	SNA Survey	Case E	M	6	Korea	Airline 5	Product Owner
102	E16	SNA Survey	Case E	M	10	USA	Airline 6	Project Manager
103	E17	SNA Survey	Case E	F	108	Singapore	Airline 7	Project Manager
104	E18	SNA Survey	Case E	M	21	Germany	Airline Alliance HQ	Program Manager
105	F10	Depth-Interview	Case F	M	72	Asia	Global engineering company	Project Director
106	F14	Depth-Interview	Case F	M	2	Asia	Global engineering company	Quality / RAMS Manager
107	F23	Depth-Interview	Case F	M	72	Germany (City 1)	Global engineering company	Senior Project Manager (DC)
108	F17	Depth-Interview	Case F	M	18	Asia	Global engineering company	Contract Manager
109	F10	SNA Survey	Case F	M	72	Asia	Global engineering company	Project Director
110	F11	SNA Survey	Case F	M	48	Asia	Global engineering company	Project Director (Commercial)
111	F12	SNA Survey	Case F	M	18	Asia	Global engineering company	System Director (Deputy to PD)
112	F13	SNA Survey	Case F	M	8	Asia	Global engineering company	Integrated Test Director
113	F14	SNA Survey	Case F	M	2	Asia	Global engineering company	Quality / RAMS Manager
114	F15	SNA Survey	Case F	M	30	Asia	Global engineering company	Documentation & Configuration Manager
115	F16	SNA Survey	Case F	M	15	Asia	Global engineering company	Integrated Test Coordinator
116	F17	SNA Survey	Case F	M	18	Asia	Global engineering company	Contract Manager
117	F18	SNA Survey	Case F	M	72	Asia	Global engineering company	Local Rep. (Rolling Stock)
118	F19	SNA Survey	Case F	M	34	Asia	Global engineering company	Local Rep. (Traction Power Systems)
119	F20	SNA Survey	Case F	M	30	Asia	External Consultant	Senior Advisor
120	F21	SNA Survey	Case F	M	24	Germany (City 1)	Global engineering company	Senior Project Manager (Rolling Stock)
121	F22	SNA Survey	Case F	M	72	Germany (City 2)	Global engineering company	Senior Project Manager (Signalling)
122	F23	SNA Survey	Case F	M	72	Germany (City 1)	Global engineering company	Senior Project Manager (DC)
123	Int01	Depth-Interview	N/a	M	N/a	Netherlands	Knowledge Management NL	KM Consultant & Researcher
124	Int02	Depth-Interview	N/a	F	N/a	USA	Full Circle Associates	KM Consultant & Virtual Facilitator
125	Int03	Depth-Interview	N/a	M	N/a	USA	Westinghouse Electrical	Senior Business Analyst / Project Manager
126	Int04	Depth-Interview	N/a	M	N/a	USA	Zipp Speed Weaponry	Production Manager
127	Int05	Depth-Interview	N/a	F	N/a	USA	Buckman International Labs	Knowledge Strategist
128	Int06	Depth-Interview	N/a	M	N/a	Germany	University Munich	Professor of Business Administration
129	Int07	Depth-Interview	N/a	M	N/a	Germany	IBM Germany GmbH	Project Manager
130	Int08	Depth-Interview	N/a	M	N/a	Germany	University Gießen	Professor of Business Administration
131	Int09	Depth-Interview	N/a	M	N/a	Great Britain	Independent Consultant	Intangibles & Stakeholder Coach
132	Int10	Depth-Interview	N/a	M	N/a	Australia	Ernst & Young	Program Manager - Asia
133	Int11	Depth-Interview	N/a	F	N/a	Hong Kong	Logic International	Founder & Owner

Source: Field data

10.12 Appendix L: Case interviews - Statistical analysis of summary questions

PART B: Opening questions	Mean	Std Dev	Sum	Variance	Min	Max
(B3) I am familiar with "knowledge management" as a term and concept.	3.583	0.687	86.000	0.472	2.000	5.000
(B4) This project team has the leadership capability to succeed in knowledge management.	3.792	0.815	91.000	0.665	2.000	5.000
(B5) What is intangible in projects or organizations is hardly worth measuring.	2.542	1.581	61.000	2.498	1.000	5.000
(B6) Does your (parent) organization's overall strategic goals include knowledge management explicitly?	3.167	1.491	76.000	2.222	0.000	5.000
PART C: Type and level of trust						
(C2) Can you identify and describe different types and levels of trust in your virtual project team, e.g. task-related vs. interpersonal trust?	0.611	0.487	11.000	0.238	0.000	1.000
(C3) Members of this virtual project team show a great deal of integrity.	4.042	0.841	97.000	0.707	2.000	5.000
(C4) I can rely on those with whom I work in this project team.	4.250	0.722	102.000	0.521	2.000	5.000
(C5) Trust is the primary facilitator focusing in knowledge management in virtual project teams.	3.417	1.037	82.000	1.076	2.000	5.000
(C6) The enhancement of trust does not happen on its own, but depends on a well managed approach.	4.292	0.841	103.000	0.707	2.000	5.000
(C7) We are usually considerate of one another's feelings in this project team.	3.917	0.909	94.000	0.826	1.000	5.000
(C8) There is no "team spirit" in this project team.	1.667	0.943	40.000	0.889	1.000	4.000
(C9) Team member reliability, consistency, and responsiveness enhances the level of trust.	4.583	0.640	110.000	0.410	3.000	5.000
PART D: Shared language and common vocabulary						
(D1) Have you experienced communication problems based on a different vocabulary or language?	0.652	0.476	15.000	0.227	0.000	1.000
(D2) Have you experienced difficulties in (sharing and) applying other parties knowledge?	0.476	0.499	10.000	0.249	0.000	1.000
(D3) Communications are poor.	2.167	1.027	52.000	1.056	1.000	5.000
(D4) In this virtual project team we share a common language - technically as well as personally.	3.783	0.778	87.000	0.605	2.000	5.000
(D5) Communications are primarily formal.	2.083	1.047	50.000	1.097	1.000	4.500
(D6) Open and honest communications support knowledge generation and sharing.	4.750	0.520	114.000	0.271	3.000	5.000
(D7) Sometimes documented knowledge isn't easy to understand.	3.979	1.065	95.500	1.135	1.000	5.000
PART E: Face-to-face interaction						
(E1) How often do you meet team members	71.359	103.042	1.642.000	10.614.325	1.000	365.000
(E3) Trust can be build virtually, thus no face-to-face contact is necessary.	2.333	1.213	56.000	1.472	1.000	5.000
(E4) Regarding (technical or personal) complex issues I definitely prefer a direct face-to-face communication instead of virtual communication channels.	4.417	1.037	106.000	1.076	1.000	5.000
(E5) Knowledge can be best shared in close personal contact with other team members.	3.833	1.106	92.000	1.222	1.000	5.000
(E6) This project would run smoother (and better project results could be realised) if more face-to-face interaction would be possible.	3.609	1.310	83.000	1.716	1.000	5.000
(E7) Knowledge can't be stored in data bases.	2.438	1.317	58.500	1.736	1.000	5.000

(continued)

PART F: Influence of informal networks	Mean	Std Dev	Sum	Variance	Min	Max
(F1) Can you identify informal networks or groups within this virtual project team?	0.818	0.386	18.000	0.149	0.000	1.000
(F3) It is not possible for an individual team member to sufficiently identify informal networks.	2.542	1.040	61.000	1.082	1.000	5.000
(F4) Informal contacts are much more suitable for effective knowledge sharing than formal ones.	3.000	0.913	72.000	0.833	1.000	4.000
(F5) Informal networks or groups are the primary driving force in virtual project teams.	2.500	1.080	60.000	1.167	1.000	5.000
PART G: Risks associated with knowledge transfer						
(G3) Are you aware of knowledge losses in the context of this project team?	0.261	0.439	6.000	0.193	0.000	1.000
(G4) The collaborative partners corporate culture isn't as open as ours (or vice versa).	3.250	1.512	65.000	2.287	0.000	5.000
(G5) Knowledge is always lost in virtual project teams.	3.042	1.207	73.000	1.457	1.000	5.000
(G6) The collaborative partners certainly have a lot more experience than we do in certain areas.	3.545	1.588	78.000	2.521	0.000	5.000
(G7) The project has established clear and efficient procedures to protect each parties knowledge sources.	3.095	1.191	65.000	1.420	1.000	5.000
PART H: Team member characters / Individual skills						
(H2) Do you think that additional (e.g. socio-cultural and technical) skills are necessary to be a good performer in a virtual project environment regarding knowledge generation and sharing ?	1.000	0.000	23.000	0.000	1.000	1.000
(H4) My work primarily involves completing independent tasks.	2.479	1.094	59.500	1.197	1.000	4.000
(H5) I'm going to learn a lot by being on this project.	4.667	0.687	112.000	0.472	2.000	5.000
(H6) No additional skills are needed in virtual project environments.	1.750	1.051	42.000	1.104	1.000	4.000
(H7) People are on this team because they are competent.	4.043	0.999	93.000	0.998	1.000	5.000
(H8) There are clear character-related team member attributes that supports virtual project work.	4.217	0.657	97.000	0.431	3.000	5.000
PART I: Additional questions						
(I1) How much time do you spend looking for knowledge (out of a 40-hr. week)?	13.500	9.678	324.000	93.667	3.000	30.000
(I2) All in all, I am satisfied with virtual project work.	3.792	1.079	91.000	1.165	1.000	5.000
(I3) Since I started working virtually, I have been able to balance my job and personal life.	2.913	1.558	67.000	2.427	0.000	5.000
(I4) Since I started working virtually, my productivity has increased.	3.261	0.895	75.000	0.802	1.000	4.000

Source: Field data

10.13 Appendix M: Case interviews – Findings derived from additional questions

Source	Keyword	Description
C	Awareness	No one cared or seemed to be getting nervous because of obvious problems, until external feedback. A lot of people are working blindly > result: projects fail [C15]
Pilot	Characteristics / Skills	Leadership skills of project leader and responsiveness of team members very important [P07]
Pilot	Characteristics / Skills	Selection criteria: Client > availability / IT Provider > technical skills
B	Characteristics / Skills	Interpersonal skills have been a dominant factor [B16]
B	Characteristics / Skills	People should possess very good technical skills, they must have confidence in their capabilities and expertise, thus being much more open to collaboration [B15]
C	Characteristics / Skills	80 % of the interviewees rated interpersonal skills as the primary selection criteria for this project
C	Characteristics / Skills	Genuine desire to help others / If people think they are 'the' experts and can't learn anything further they won't share a piece of knowledge [C11]
D	Characteristics / Skills	Not being introverted [D10] [D16]
D	Characteristics / Skills	Technical skills are the primary selection criteria [D13] [D16]
E	Characteristics / Skills	Open minded, proactive, flexible, positive happy person and a good communicator [E10] [E12] [E15]
F	Characteristics / Skills	People have been chosen primarily because of technical competences
F	Characteristics / Skills	Good communication skills important (Interpersonal skills not valued very much)
Int	Characteristics / Skills	It takes a special type of person to be able to manage virtual communication and still remain productive and involved [Int4]
Int	Characteristics / Skills	People are promoted for higher management positions because of their facilitation experience. You need those skills to be effective in this company [Int5]
Int	Characteristics / Skills	A great deal of sensitivity is needed e.g. to assess peoples mood during a telephone conversation [Int7]
A	Communication	Initial problem solving activities were not very successful - a lot of misunderstandings [A23]
D	Context	Competing project parties: No trust > No sharing / 100% different vocabulary, acronyms, attitudes and working habits / It took about three weeks to establish a sufficient relationship (with the help of the two vice presidents of the companies) [D13]
E	Context	Flow of knowledge from the alliance to my parent airline was hard to channel and apply within the company (Management cultures, different complexities, different PM models and approaches as well as different organisational, business and market context [E10]
C	Cultural change	Unsuccessful cultural change program (sustainability!?) managed by 'big five' consulting firm [C13]
Pilot	Discipline	Team members discipline is important [P08]
A	Distance	Geographical distance is a barrier [A18] / Personal touch is missing [A20]
A	Distance	All participants urged the need for human proximity to foster or even enable knowledge exchange / Distant team members meet to allow 'active' knowledge transfer [A23]
F	Distance	One can't exchange enough background information to ensure a common understanding of issues [F16] [F10]
B	Facilitation	Consultant activities focused on identification and discussion of 'virtual compatible' characters and personalities within the project team [B15]
C	Facilitation	Two offsite kick-off meetings facilitated by an psychologist [C13]
D	Facilitation	Mentoring > Guiding newcomers to entry points of the organisational knowledge system [D10]

(continued)

B	Interdisciplinary	In (virtual) interdisciplinary environments you haven't really the possibility to assess other team members work [B16]
B	Knowledge exchange	Not all sorts or forms of knowledge can be shared virtually e.g. very unstructured knowledge [B15]
E	Knowledge exchange	Be prepared to share greater amounts of knowledge in rare F2F meetings [E10]
D	Knowledge documentation	Documented knowledge is often old and outdated ("Information graveyards") [D10]
D	Knowledge documentation	We don't document issues like how we work or how we do it [D16]
D	Knowledge documentation	Much more problems when applying codified knowledge > scanning documents for valuable knowledge is very time consuming [D13]
A	Knowledge exchange	Localised knowledge / Instead of asking others for help, one tries to solve a problem alone [A18] / No real knowledge exchange [A23]
F	Knowledge exchange	I invite younger team members in my office to share my knowledge actively [F10]
Int	Knowledge exchange	Knowledge can't be separated from its human carrier without loosing some parts of it [Int8]
B	Knowledge generation	Global unit plays a key role in the synthesis of new knowledge [B16]
C	Listening	People should be able to genuinely ask questions and genuinely listen to other people [C15]
C	People	Humans are social animals [C11]
D	People	High team member fluctuation because of scarce expert resources [D10]
F	People	His contact persons in this project are changing from month to month [F16]
F	People	Competence problems in head quarters > Interpersonal quarrels > Bad atmosphere > only formal documentation > poor knowledge sharing [F23]
F	People	The company has selected those who were 'available', whereas other firms would chose the best persons for the job [F16] [F23]
F	People	A good virtual project manager uses a simple language and decides quickly [F14]
Int	People	More problems (Motivation / Direction) with team members from hierarchical organisations [Int2]
Int	People	Those people from the organizational hierarchy who put the most effort in virtual teams were not rewarded, instead local people got promoted [Int9]
Int	People	People who can't contribute should not be in a virtual team [Int5]
Int	People	Selection of team members: The question is who has to be involved instead of who is most suitable [Int10]
Int	People	China: In reality, a well known and trusted team member will be chosen instead of an obviously better qualified individual. KM is a very new concept compared to the old and strong (Asian) work culture [Int11]
Int	Processes	Difference between (project) task and (virtual team) process, which has to be balanced [Int2]
Int	Processes	We know that it doesn't work, but its company policy [Int10]
C	Socialising	Beginning of each F2F meeting "socialising phase" e.g. how is everyone feeling or how was the weekend > ensure that everyone is present / Max meeting time: one hour [C12]
Int	Socialising	Reaffirm social team links and connections regularly [Int5]
Int	Socialising	People must have the chance to establish social relationships [Int8]
B	Speed	React fast when an answer or action is required > that's why this consortium works [B14]
F	Speed	Proactive behaviour > in case of problems > immediate phone call [F23]
B	Stress	Working virtually means a lot of stress (or better emphasis) on all of us [B15]
D	Technology	Efficiency of knowledge databases less than 30% / Knowledge databases are not used [D10]
Int	Technology	You can't assume that the whole team will use software effectively [Int9]
Int	Technology	Only insufficient use of innovative IT like web conferencing by senior management [Int10]
Int	Technology	"The drunken man and the lantern: Having lost his key, the man only searches for the key in the light of the lantern (thus IT solutions), while knowing that the key certainly could be found elsewhere" [Int6]

(continued)

C	Telephone conference	Special (moderator) skills needed > project manager hasn't a clue what is going on during the virtual meeting [C15]
D	Telephone conference	Telephone conferences not efficient, because participants tend to work in parallel e.g. reading email > no real added value (Key word: discipline) [D10]
D	Telephone conference	Phone conferences with more than 10 people are a waste of time > people are not focused and concentrated [D13]
Int	Telephone conference	Importance of setting up a clear agenda in global conference calls [Int5]
Int	Telephone conference	Every day 15 minutes telephone conference (Jam-Sessions) with relevant team members > Used to check and ensure a common understanding [Int7]
F	Training	Training may elaborate the cultural forces at work, but the problems are still there [F23]
Int	Virtual work	Strategic virtual project: Underestimated how much 'housekeeping" was necessary [Int5]
C	Virtual work	Still a lot of misunderstanding and assumptions that virtual work is the same as collocated one [C15]
Int	Virtual work	Only 5 out of 80 teams were successfully from a virtual teaming point of view > in these teams the technical project manager realised that he can't handle the social leadership alone > Solution: One deliverables leader and one high trust 'social' leader [Int9]
Int	Virtual work	Difference between technical and social interfaces > introverted programmes or engineers link primarily via a more technical interface, whereas project managers utilise a more social interface [Int8]
Int	Virtual work	Virtual settings can be as effective as traditional ones, but it takes at least three times as long [Int4]
Int	Virtual work	Constructs from the hierarchical structures often doesn't work in virtual team environments [Int9]

Source: Field data

10.14 Appendix N: SNA – Background information regarding graph analysis, index calculation and correlation analysis

The following table provides background information regarding the calculation, display and interpretation of SNA results. For each case study setting seven relational attributes (variables) as defined in appendix E have been analysed using the described measures / indices.

Graphs	
All graphs or sociograms have been developed using the IKNOW tool (based on Spring Embedding algorithm) as well as NETDRAW (part of UCINET package), whereas the later one provides more and sophisticated functionalities / features.	
Relationships	Wherever possible (based on graph density and visibility of tie strength) significant relationships between nodes have been investigated.
Central / Peripheral actors	This measure simultaneously fits a core/periphery model to the data network, and identifies which actors belong in the core and which belong in the periphery (Borgatti, Everett & Freeman 2002). The result tables indicate an actors position as central (c) or peripheral (p). > UCINET: Network > Core/Periphery > Categorical
Subgroups	Divisions of actors into cliques or "sub-groups" can be a very important aspect of social structure. Knowing how an individual is embedded in the structure of groups within a net may also be critical to understanding his/her behaviour. The result tables picture group membership of actors (nodes) starting with the strongest group, thus ‘1’. > IKNOW: Network Groups
<u>**Remark**</u>: To support the sometimes vaguely visual graph analysis, especially targeting the identification of subgroups, ***hierarchical clustering*** (Borgatti, Everett & Freeman 2002) has been used. Given a symmetric n-by-n matrix representing similarities or dissimilarities among a set of n items, the algorithm finds a series of nested partitions of the items. The different partitions are ordered according to decreasing [increasing] levels of similarity [dissimilarity]. > UCINET: Tools > Clustering > Hierarchical	
Actor Indices	
All actor indices have been computed using the IKNOW tool. For each actor index the result tables show the top 20 per cent (green colour) as well as the lowest 20 per cent (red colour) of the spectrum. For example: Given a group size of 23 actors, the top five actors will be indicated as ‘1’,’2’, etc. where two or more actors may receive the same ranking if their index results are identical. The lower end will be presented in reverse order, e.g. ‘23’, ‘22’, ‘21’, etc.	
Actor Simple Prestige	The simplest actor-level measure of prestige is the in-degree of each actor. The idea is that ***actors who are prestigious*** tend to receive many nominations or choices. The larger this index is, the more prestigious is the actor. Maximum value is 1; that is, when an actor is chosen by all other actors.
Actor Proximity Prestige	The form of the prestige index counts only nodes who are adjacent to an actor. One can generalise this index by defining the ***influence domain*** of an actor as a set of nodes who are both directly and indirectly linked to the actor.
Actor Degree Centrality	Centrality in general is a structural attribute of nodes in a network. It Is a measure of the contribution of network position to the importance, influence, prominence of an actor in a network. Degree centrality in detail calculates the degree and normalised degree centrality of each actor and gives the overall network degree centralisation (Wassermann & Faust 1999). Degree centrality measures ***network activity***. Actors who have unusually high out-degree are actors who are able to exchange with many others, or make many others aware of their views. Actors who display high out-degree centrality are often

(continued)

	said to be influential actors (Wassermann & Faust 1999)
Actor Closeness Centrality	Calculates the farness and normalised closeness centrality of each vertex and gives the overall network closeness centralisation. Closeness centrality can be thought of as an index of the expected time until-arrival for things flowing through the network via optimal paths (***Speed of transmission***) (Borgatti, Everett & Freeman 2002). In a diffusion process, a node that has high closeness centrality is likely to receive information more quickly than others (Wassermann & Faust 1999). Degree centrality measures in general might be criticised because they only take into account the immediate ties that an actor has, rather than indirect ties to all others. One actor might be tied to a large number of others, but those others might be rather disconnected from the network as a whole. In a case like this, the actor could be quite central, but only in a local neighbourhood.
Actor Betweenness Centrality	Calculates the betweenness and normalised betweenness centrality of each vertex and gives the overall network betweenness centralisation. Betweenness centrality measures ***information control*** (Borgatti, Everett & Freeman 2002). Betweenness centrality views an actor as being in a favoured position to the extent that the actor falls on the geodesic paths between other pairs of actors in the network. That is, the more people depend on me to make connections with other people, the more power I have (Wassermann & Faust 1999). Care should be taken in interpreting betweenness for directed data. In a diffusion process, a node that has betweenness can control the flow of information, acting as a gatekeeper. That node may also serve as a liaison between disparate regions of the network. In an exchange process, high betweenness node can serve as broker. Networks that contain individuals with high betweenness are vulnerable to having information flows disrupted by power plays or key individuals leaving (Cross & Parker 2004)

Brokerage measures

Given (a) a graph, and (b) a partition of nodes, this procedure proposed by Gould and Fernandez (1989) measures five kinds of brokerage. Brokerage occurs when, in a triad of nodes A, B and C, A has a tie to B, and B has a tie to C, but A has no tie to C. That is, A needs B to reach C, and B is therefore a broker. When A, B, and C may belong to different groups, 5 kinds of brokerage are possible. The five kinds are named using terminology from social roles. In the description below, the notation G(x) is used to indicate the group that node x belongs to. Important: It is assumed that a-->b-->c. For example, a (the source node) gives information to b (the broker), who gives information to c (the destination node).

Coordinator: Counts the number of times b is a broker and G(a) = G(b) = G(c), that is, all three nodes belong to the same group.

Consultant: Counts the number of times b is a broker and G(a) = G(c), but G(b) ≠ G(a); that is, the broker belongs to one group, and the other two belong to a different group.

Gatekeeper: Counts the number of times b is a broker and G(a) ≠ G(b) and G(b) = G(c), that is, the source node belongs to a different group.

Representative: Counts the number of times b is a broker and G(a) = G(b) and G(c) ≠ G(b). That is, the destination node belongs to a different group.

Liaison: Counts the number of times b is a broker and G(a) ≠ G(b) ≠ G(c). That is, each node belongs to a different group.

The routine calculates these measures for each node in the network, and also the total of the five. The program also computes the expected values of each brokerage measure given the number of groups and the size of each group. That is, the expected values under the assumption that brokerage is independent of the group status of nodes. A final output divides the observed brokerage values by these expected scores.

> UCINET: Network > Ego Networks > Brokerage

(continued)

Network indices	
Network Density	The density of a valued network is the total of all values divided by the number of possible ties (Borgatti, Everett & Freeman 2002). As a group gets bigger, the proportion of all of the ties that could (logically) be present - density - will fall, and the more likely it is that differentiated and partitioned groups will emerge. Populations with high density respond differently to challenges from the environment than those with low density; populations with greater diversity in individual densities may be more likely to develop stable social differentiation and stratification (Hannemann 2001). > UCINET: Network > Properties > Density
Network Cohesion	Constructs a distance or generalised distance matrix between all nodes of a graph. The strength of a path is equal to the strength of its weakest link. The algorithm finds the number of edges in the strongest path between each pair of nodes (Borgatti, Everett and Freeman 2002). Referring to Wassermann and Faust (1999) one can expect greater homogeneity among persons who have frequent face-to-face contact or who are connected through intermediaries and less homogeneity among persons who have less frequent contact. Further, it can be expected that the more individuals are tied into a network, the more they are affected by group standards. > UCINET: Network > Cohesion > Distance
E-I Index	Given a partition of a network into a number of mutually exclusive groups then the E-I index is the number of ties external to the groups minus the number of ties that are internal to the group divided by the total number of ties. Possible scores range from –1 to +1. As the index approaches +1, all the links would be external, whereas a score of –1 would indicate that all links are internal. From a time or energy based point of view, we can assume that the more internal links one has, the fewer links one can foster outside a sub-unit. Thus internal links represent an "**opportunity cost**" to the sub-unit (Krackhardt & Stern 1998). > UCINET: Network > Properties > E-I Index
QAP-Correlation analysis	
The procedure is principally used to test the **association between networks** (Borgatti, Everett & Freeman 2002). The algorithm proceeds in two steps. In the first step, it computes Pearson's and Jaccard correlation coefficient between corresponding cells of the two data matrices, hence in this research the project–related sharing network and the investigated variable. In the second step, it randomly permutes rows and columns (synchronously) of one matrix and recomputes the correlation and other measures. The second step is carried out hundreds of times in order to compute the proportion of times that a random measure is larger than or equal to the observed measure calculated in step 1. A low proportion (< 0.05) suggests a strong relationship between the matrices that is unlikely to have occurred by chance. *Pearson correlations* range from -1.00 (meaning that the two actors have exactly the opposite ties to each other actor), through zero (meaning that knowing one actor's tie to a third party doesn't help us at all in guessing what the other actor's tie to the third party might be), to +1.00 (meaning that the two actors always have exactly the same tie to other actors - perfect ***structural equivalence***). Where densities are very low, and ties are not reciprocated, correlations can be very small. The Pearson correlation coefficient gives considerable weight to large differences between particular scores in the profiles of actors (because it squares the difference in scores between the vectors). This can make the correlation coefficient somewhat sensitive to extreme values (in valued data like in this research) and to data errors (Hannemann 2001), therefore *Jaccard coefficient* is used in parallel. This index is especially useful in low density networks, because where density is very low, the "matches" "correlation" and "distance" measures can all show relatively little variation among the actors, and may cause difficulty in discerning structural equivalence sets. > UCINET: Tools > Statistics > Matrix (QAP) > QAP-Correlation	

Source: Developed for this research

10.15 Appendix O: SNA – Overview of case-related measure and index results [22]

Case B

Contact

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	3		2	10	11		1	1,7000 (Std Dev = 2,0695)	Distance-based cohesion = 0,739
B11	p	3		9				11		
B12	p	2	11	10	11	11		1		
B13	p	3	10					1		
B14	p	1	10	9				1		
B15	c	1	1	1	1	1				
B16	p	2			2	1				
B17	p	2	11	11	9			1		
B18	c	2	1	1	1	1	1			
B19	c	1	2		2	1				
B20	c	1	2		2	1		11		

Get Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	3		1	11	11		1	2,2545 (Std Dev = 2,0513)	Distance-based cohesion = 0,688
B11	c	3		10	10	9		11		
B12	p	1	9		10	10	2	1		
B13	c	3	10	10		1		1		
B14	c	2						1		
B15	c	1	1	2	1	1				
B16	c	1		2	1	1				
B17	p	2	11	11				1		
B18	c	1	2	2	1	1	1			
B19	c	2	3		2	1				
B20	c	2	4		2	1		10		

Give Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	3		1	11	11		1	2,2455 (Std Dev = 2,0635)	Distance-based cohesion = 0,706
B11	c	2		11	10	9		11		
B12	c	1	10		9	10	2	1		
B13	p	3	10	10				1		
B14	c	3	9					1		
B15	c	1	1	2	1	1				
B16	c	1		2	1	1				
B17	p	2	11	11				1		
B18	c	1	2	2	1	1	1			
B19	c	2	4		2	1				
B20	c	2	3		2	1		10		

Knowing

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	3		1	11	11		1	3,3818 (Std Dev = 2,0932)	Distance-based cohesion = 0,764
B11	p	3	10	11	10	9		11		
B12	p	1			9	10	2	1		
B13	c	2	9	9				1		
B14	c	2						1		
B15	c	1	1	2	1	1				
B16	c	1	3	2	1	1				
B17	c	2	11	10			2	1		
B18	c	1	2	2	1	1	1			
B19	c	3			2	1				
B20	c	2		9		1		10		

Value

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	1	3	1	11	11		1	3,3182 (Std Dev = 2,0579)	Distance-based cohesion = 0,729
B11	c	3	10	11	10	9		11		
B12	p	1			9	10	2	1		
B13	c	3	10	9				1		
B14	c	2						1		
B15	c	1	1	2	1	1				
B16	c	1	2	2	1	1				
B17	p	2	11	10				1		
B18	c	2	2	2	1	1	1			
B19	c	3			2	1				
B20	c	2			2	1		10		

Access

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	3		1	11	11		1	3,0545 (Std Dev = 2,0264)	Distance-based cohesion = 0,735
B11	c	2		11	10	9		11		
B12	p	1	9		9	10	2	1		
B13	p	3	10	9				1		
B14	c	2						1		
B15	c	1	1	2	1	1				
B16	c	1	2	2	1	1				
B17	c	2	11	10				1		
B18	c	1	1	2	1	1	1			
B19	c	3			2	1				
B20	c	2	3		2	1		10		

Cost

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
B10	p	2		1	11	11		1	3,3636 (Std Dev = 2,1647)	Distance-based cohesion = 0,795
B11	p	3	10	11	10	9		11		
B12	p	1	10		9	10	2	1		
B13	c	2	9	10				1		
B14	c	3						1		
B15	c	2	2	2	1	1				
B16	c	1	3	2	1	1				
B17	c	2	11	11			2	1		
B18	c	1	1	2	1	1	1			
B19	c	1			2	1				
B20	c	3		10		1		10		

[22] Developed from field data using IKNOW (2003) and UCINET (2004)

Case A

Contact

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	2	3		1	1	1		1,0997 (Std Dev = 2,5152)	Distance-based cohesion = 0,774
A12	c	1			5					
A13	c	2			5	4		24		
A14	p	4						27		
A15	p	4								
A16	p	4	26	25				1		
A17	p	2	2	1				25		
A18	c	4								
A19	c	3						2		
A20	c	3			2	2				
A21	p	3	26	26				1		
A22	c	3						26		
A23	c	1						5		
A24	p	5						1		
A25	p	2	1	1				25		
A26	p	1		1						
A27	c	1						3		
A28	c	1								
A29	p	1		5				23		
A30	p	5	26	24						
A31	c	2	2		4	4		4		
A32	p	4	4	1				25		
A33	c	2	4		3	3				
A34	p	4		2				1		
A35	p	3	25	27		2				
A36	p	5	27	26				1		
A37	c	3								

Get Information

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	1	3		1	1	1		1,0641 (Std Dev = 2,3571)	Distance-based cohesion = 0,802
A12	c	1			1	1		4		
A13	c	1	4					24		
A14	p	3		26	27			26		
A15	p	3								
A16	p	3	25	26	27			1		
A17	c	1	2	1				27		
A18	c	3			1	1				
A19	c	3						3		
A20	c	1			1	1				
A21	p	2	27	26	27			1		
A22	c	2						24		
A23	c	2								
A24	p	4			26			1		
A25	p	3	1	1				27		
A26	p	4		2						
A27	c	4						2		
A28	c	4								
A29	p	4		1				25		
A30	p	4	25	25	26					
A31	c	2			1	1		4		
A32	p	2		1				27		
A33	c	1	3			1				
A34	p	2		2				1		
A35	p	5	27	27		1				
A36	p	5	26	25	26			1		
A37	c	5						25		

Give Information

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	1	1		1	1	1		0,9672 (Std Dev = 2,2463)	Distance-based cohesion = 0,820
A12	c	2			1	1		4		
A13	c	1						24		
A14	p	3		26	27			26		
A15	p	3		26						
A16	p	3	24		27			1		
A17	c	2			1	1				
A18	c	3			1	1				
A19	c	4						3		
A20	c	1			1	1				
A21	p	4	27	26	27			1		
A22	c	1			1	1				
A23	p	2		1						
A24	p	4	25					1		
A25	p	1	2	1				27		
A26	p	4		1						
A27	c	2						2		
A28	c	2								
A29	p	4		1						
A30	p	5	24		26					
A31	p	2	3	1				4		
A32	p	4	3	1				27		
A33	c	1	2		1	1				
A34	p	3						1		
A35	c	5		27		1				
A36	p	5	26	26	27			1		
A37	c	3						25		

Knowing

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	1			1	1	1		1,0954 (Std Dev = 2,3219)	Distance-based cohesion = 0,857
A12	c	1			1	1		4		
A13	c	2						26		
A14	p	4	24	24	25			25		
A15	c	4	23		24			23		
A16	p	4	27	27	27			1		
A17	c	2	2	1				27		
A18	c	4		23						
A19	c	3						3		
A20	c	1			1	1				
A21	p	5	26	26	26			1		
A22	c	2			1	1				
A23	c	1		1						
A24	c	3						1		
A25	c	2	1	1				27		
A26	c	4	3	1						
A27	c	3			1	1		2		
A28	c	1								
A29	c	3								
A30	c	5			25					
A31	c	1			1	1		4		
A32	c	2		1				27		
A33	c	2			1	1				
A34	c	4		1				1		
A35	c	3	25	25		1				
A36	p	5			25			1		
A37	c	3						24		

Value

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	1			1	1	1		0,8604 (Std Dev = 2,1924)	Distance-based cohesion = 0,865
A12	p	2								
A13	c	2						25		
A14	p	4		25	26			26		
A15	p	4								
A16	p	4	27	27	27			1		
A17	p	1	2	1				27		
A18	c	4								
A19	c	2						3		
A20	c	1	4		1	1				
A21	p	3	26	27	27			1		
A22	c	1	4					23		
A23	p	2		1						
A24	p	3						1		
A25	p	1	1	1				27		
A26	p	4		1						
A27	c	3			1	1		2		
A28	c	3								
A29	p	3		1						
A30	p	3		24	25			1		
A31	c	2			1	1		4		
A32	p	2	4	1				27		
A33	c	1	3		1	1				
A34	p	4		1						
A35	c	5	26	26		1				
A36	p	5	25	24	25			1		
A37	c	5						24		

Access

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	2			1	1	1		1,1524 (Std Dev = 2,3457)	Distance-based cohesion = 0,827
A12	c	1				1		4		
A13	c	2	4					26		
A14	p	3	25	24	25			25		
A15	c	3			24					
A16	p	3	27	27	27			1		
A17	c	2	2	1				27		
A18	c	3								
A19	c	3						3		
A20	c	2			1	1				
A21	p	4	27	26	26			1		
A22	c	1			1	1				
A23	c	1								
A24	c	4						1		
A25	c	2	1	1				27		
A26	c	4		1						
A27	c	3						2		
A28	c	4								
A29	c	1		1						
A30	c	5			24			1		
A31	c	1	3		1	1		4		
A32	c	1	4	1				27		
A33	c	2	2		1	1				
A34	c	4								
A35	c	5	26	25		1				
A36	c	5	24		24			1		
A37	c	4						24		

Cost

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
A11	c	1			1	1	1		1,3632 (Std Dev = 2,4756)	Distance-based cohesion = 0,873
A12	c	1			1	1		4		
A13	c	1						24		
A14	p	4	24	25	26			26		
A15	c	4								
A16	p	4	27	27	27			1		
A17	c	1	1	1				27		
A18	c	4								
A19	c	1	3					3		
A20	c	1			1	1				
A21	p	4	26	25	26			1		
A22	c	4						24		
A23	c	2	4							
A24	c	3						1		
A25	c	2	2	1				27		
A26	c	2	4	1						
A27	c	2						2		
A28	c	2								
A29	c	2	2	1						
A30	c	3						1		
A31	c	3			1	1		4		
A32	c	3		1				27		
A33	c	3			1	1				
A34	c	5								
A35	c	5	25	26		1				
A36	c	5	23	24	25			1		
A37	c	2						25		

Case C

Contact

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1	1	1	1	1		9	4,2917 (Std Dev = 1,5405)	Dist.-based coh. = 0,718
C11	c	1		1	1	1		9		
C12	c	1	2	1	1	1		9		
C13	c	1		1	9	9		9		
C14	p	2	7	1	1	1		9		
C15	c	2	1	1	1	1		1		
C16	p	2	8	9	8	1		1		
C17	p	3	9	9	8	1		1		
C18	c	2	2	1	1	1	1	1		

Get Information

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1	3	9		1		9	3,5694 (Std Dev = 2,0332)	Dist.-based coh. = 0,583
C11	c	1	2	9		1		9		
C12	c	1	7	9		1		9		
C13	c	1		9		1		9		
C14	c	2		9		1		9		
C15	c	2	1	1	1	1		1		
C16	p	2		1	1	1		1		
C17	p	2	9	1	9	9		1		
C18	p	3	8	1	1	1	1	1		

Give Information

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1		1	1	1		9	3,6806 (Std Dev = 1,6144)	Dist.-based coh. = 0,610
C11	c	1	1	1	1	1		9		
C12	c	1	2	1	1	1		9		
C13	p	1	2	1	1	1		9		
C14	p	2		1	1	1		9		
C15	c	2	2	1	1	1		1		
C16	p	2	8	1	1	1		1		
C17	p	2	9	1	1	1		1		
C18	p	3	9	1	1	1		1		

Knowing

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1	8	1	1	1		9	3,0556 (Std Dev = 1,6063)	Dist.-based coh. = 0,713
C11	c	1	1	1	1	1	1	9		
C12	p	1	9	1	1	1		9		
C13	p	1	3	1	9	9		9		
C14	p	2		1	1	1		9		
C15	c	2	2	1	1	1		1		
C16	c	2	8	9	8	1		1		
C17	c	2		9	8	1		1		
C18	c	3		9		1		1		

Value

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1		1	1	1		9	3,4722 (Std Dev = 1,6070)	Dist.-based coh. = 0,734
C11	c	1	1	1	1	1	1	9		
C12	p	1		1	8	8		9		
C13	p	1		1	9	9		9		
C14	p	2	3	1		7		9		
C15	c	2	2		2	1		1		
C16	p	2	7	8		1		1		
C17	p	2	8	9	8	1		1		
C18	p	3	9	9	8	1		1		

Access

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	c	1		1	1	1			3,4306 (Std Dev = 1,7387)	Dist.-based coh. = 0,736
C11	c	1	1	1	1	1	2			
C12	p	1	9	1	7	7		9		
C13	p	1	2	1	8	8		9		
C14	c	2	9	1	1	1				
C15	c	2	1	1	1	1		1		
C16	c	2	9	9	6	1		1		
C17	p	2		9	9	9		1		
C18	c	3	2	1	1	1	1	1		

Cost

NODE	Graph		Indices							
	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
C10	p	1	2	1	1	1		9	4,6389 (Std Dev = 1,0712)	Dist.-based coh. = 0,924
C11	c	2		1	1	1	1	9		
C12	c	1	2	1	1	1		9		
C13	p	1	2	1	9	9		9		
C14	c	1	2	1	1	1		9		
C15	c	2	1	1	1	1		1		
C16	c	2	8	9	8	1		1		
C17	c	2	9	9	8	1		1		
C18	p	3	9	9	8	1		1		

Case D

Contact

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	2			3		1	14	1,9250 (Std Dev = 1,8265)	Distance-based cohesion = 0,583
D11	p	2			3	3				
D12	p	2	14	16	15	14		16		
D13	p	2	16	16	16	15		15		
D14	c	1	15	15	14	13		1		
D15	p	3					4	13		
D16	p	3	13	14	13	16				
D17	p	3								
D18	c	2	2			2	3			
D19	c	1	4	2	1	3	2			
D21	c	1								
D22	p	3						4		
D23	p	4						5		
D24	c	1	1	1		3		3		
D25	c	1	3	2		1		2		
D26	c	3		1	2					

Get Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	1		2	3		1	13	2,2167 (Std Dev = 1,9565)	Distance-based cohesion = 0,568
D11	c	1			4			13		
D12	p	1		15	15	15		16		
D13	p	1	15	16				15		
D14	c	2	16	15	14			2		
D15	c	3					2			
D16	p	3	14	15	16	16		14		
D17	c	3			14	14				
D18	c	1	3	1		2	4			
D19	c	3	4	2	1	2	3			
D21	c	2		3	4					
D22	c	3			2	1		3		
D23	c	4	13			14		2		
D24	c	2	1			3		1		
D25	c	2	2	1		1		1		
D26	c	2		1	3					

Give Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	2	3	1	2		3	14	2,1833 (Std Dev = 1,9407)	Distance-based cohesion = 0,622
D11	c	2			2	2		14		
D12	p	2		14	15	15		16		
D13	c	2	15	15				14		
D14	c	1	13	13	14	14		2		
D15	c	1				1	1			
D16	p	3	16	16	16	16		15		
D17	p	2		13	14	14				
D18	c	3	4	1		2	4	14		
D19	c	3			2	2	2			
D21	c	1								
D22	c	3			1	1		3		
D23	c	4	14		14	15		2		
D24	c	1	1		1			1		
D25	c	1	2	1		1		1		
D26	c	3								

Knowing

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	1					1	14	2,7875 (Std Dev = 2,0085)	Distance-based cohesion = 0,616
D11	c	1			3			14		
D12	p	1	15	16	16	15		16		
D13	c	1	15	16	14			15		
D14	p	2	16	16	15	14		1		
D15	p	3					2	13		
D16	p	3	14	15	15	16				
D17	p	3								
D18	c	1	2	2		2	3			
D19	c	2	3	2	1	4	1			
D21	c	2		3						
D22	c	3			2	3	4	3		
D23	p	4				14		4		
D24	c	2	1			4		2		
D25	c	2	4	2		1		2		
D26	p	3	2	1	2					

Value

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	1		2	3		1	14	2,8167 (Std Dev = 2,0453)	Distance-based cohesion = 0,607
D11	c	1		3	4			14		
D12	p	2	15	15	16	15		16		
D13	c	2		15				15		
D14	c	3	13	16	15			1		
D15	c	3					2			
D16	p	3	16	14	16	16		13		
D17	p	1	14	14	14	14				
D18	c	1	2	1		2	4			
D19	c	2	3	1	1	3	3			
D21	c	2		3				5		
D22	c	3	3		4	3		3		
D23	c	4	14			14		4		
D24	c	1	3			3		2		
D25	c	2	1	1		1		2		
D26	c	3		1	2					

Access

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	1		2	2		2	14	2,4750 (Std Dev = 1,8415)	Distance-based cohesion = 0,555
D11	c	2			2			14		
D12	p	2	16	16	16	15		16		
D13	c	2	16	16				15		
D14	p	3	15	15	14			1		
D15	c	3					3	13		
D16	p	3	15	14	15	16				
D17	c	3				14				
D18	c	1	3	1		1	4			
D19	c	2	1	1	1	2	1			
D21	c	1		3	3			5		
D22	c	3			2			3		
D23	c	4	14			14		4		
D24	c	1	2			2		2		
D25	c	1	2	1		1		2		
D26	c	2		1	1	2				

Cost

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
D10	c	1	1	1	2		2		2,4458 (Std Dev = 2,1402)	Distance-based cohesion = 0,570
D11	c	1		3	3			14		
D12	c	2	16	15	15	14		15		
D13	p	2	16	16	16	16		16		
D14	c	3	16	14	15	14		1		
D15	c	3				16	4	13		
D16	p	3	15	14	15	15				
D17	c	3	15							
D18	c	2	3	1	1	3	3			
D19	c	1	2	1		2	1			
D21	c	2		3	3					
D22	c	3			3	3		4		
D23	c	4						5		
D24	c	2	4			2		3		
D25	c	1	4	2		1		2		
D26	c	1	5		3	4				

Case E

Contact

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1						1	1,6944 (Std Dev = 1,6967)	Dist.-based coh. = 0,694
E11	c	1	2		3		2	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1		7	3	1	3	1		
E14	c	2	3		2	1		1		
E15	p	2	8	8	7	7		1		
E16	p	2		2	9	9		1		
E17	c	2	9	9		1		1		
E18	p	3	7		8	8		9		

Get Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	3					1	2,0139 (Std Dev = 1,8892)	Dist.-based coh. = 0,690
E11	c	1	2		2	1	1	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1		9		1		1		
E14	p	2	8		2	1		1		
E15	p	2	9	9	7	7		1		
E16	p	2	8	2	9	9		1		
E17	c	2	9	9		1		1		
E18	c	3		3	8	8		9		

Give Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	2					1	1,9861(Std Dev = 1,8671)	Dist.-based coh. = 0,738
E11	c	1			2	1	1	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1		9		1		1		
E14	p	2	2		2	1		1		
E15	p	2	9	9	7	7		1		
E16	p	2	7	2	9	9		1		
E17	c	2	8	9		1		1		
E18	c	3	7		8	8		9		

Knowing

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	2			1		1	3,0417 (Std Dev = 2,3240)	Dist.-based coh. = 0,838
E11	c	2			2		1	1		
E12	c	1	1	1	1	1	2	8		
E13	c	1	8	9		1		1		
E14	c	3			2	1		1		
E15	p	2	9	9	7			1		
E16	p	2	3	2	9	9		1		
E17	c	2	9	9		1		1		
E18	p	1	3		8	8		9		

Value

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	2					1	2,9167 (Std Dev = 2,1522)	Dist.-based coh. = 0,819
E11	c	1	2		2	1	1	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1	7	9		1		1		
E14	c	2			3	1		1		
E15	p	2	9	9	7			1		
E16	p	2	2	2	9	9		1		
E17	c	2	8	9		1		1		
E18	p	3			8	8		9		

Access

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	2					1	2,5000(Std Dev = 1,9720)	Dist.-based coh. = 0,721
E11	c	1			2	1	1	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1		9	3	1		1		
E14	c	2	2		2	1		1		
E15	p	2	9	9	7	7		1		
E16	p	2	3	2	9	9		1		
E17	c	2	8	9	3	1		1		
E18	p	3	3		8	8		9		

Cost

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
E10	c	1	2	3				1	3,0417 (Std Dev = 2,3240)	Dist.-based coh. = 0,840
E11	c	1	8	9	2	1	1	1		
E12	c	1	1	1	1	1	1	8		
E13	c	1		9	2	1		1		
E14	c	2	3	3	2			1		
E15	p	2	7	9	7	7		1		
E16	p	3		2	9	9		1		
E17	c	2	9	9	2	1		1		
E18	p	2	3	3	8	8		9		

Case F

Contact

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	1	1	1	1		13	3,4176 (Std Dev = 2,1333)	Distance-based cohesion = 0,655
F11	c	1			1	1		13		
F12	c	2	2	1	1	1		13		
F13	c	1	2	1	1	1		13		
F14	c	2	11	13	13	13		14		
F15	c	2		1	1	1		13		
F16	c	3		1	1	1		13		
F17	c	1	3	1	1	1	2	13		
F18	c	2		13	11	12	2	14		
F19	c	3		13		1		13		
F20	c	3		1	1	1		13		
F21	p	4	12	13		1	1	2		
F22	p	4	13		14	14		1		
F23	p	3	14	14	12	12		3		

Get Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	2		1	1		14	3,4505 (Std Dev = 2,0980)	Distance-based cohesion = 0,643
F11	c	1			1	1		14		
F12	c	2	1		1	1		14		
F13	c	1	3		1	1		14		
F14	p	2	14	14	13	1		14		
F15	c	3			1	1		14		
F16	c	3			1	1		14		
F17	c	1	4		12	13		14		
F18	c	2		13		1		14		
F19	c	3		13	12	12		14		
F20	c	3			1	1		14		
F21	c	2	12		1	1	1	2		
F22	p	4	13	1	14	14		1		
F23	p	4	14		12	13		2		

Give Information

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	1		1	1		13	3,2747 (Std Dev = 2,0572)	Distance-based cohesion = 0,675
F11	c	1			1	1		13		
F12	c	2	1		1	1		13		
F13	c	1	2		1	1		13		
F14	p	2	13	14	12	1		13		
F15	c	3			1	1		13		
F16	c	3	4		1	1		13		
F17	c	1	5		1	1		13		
F18	c	2		13	13	13		14		
F19	c	3			12	12		13		
F20	c	2			1	1		13		
F21	c	4	11		1	1	1	2		
F22	p	3	12	1	14	14		1		
F23	p	4	14	13	13	13		3		

Knowing

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	1	2	1	1		13	3,5440 (Std Dev = 1,6889)	Distance-based cohesion = 0,806
F11	c	1	2	2	1	1		13		
F12	c	1	2	2	1	1		13		
F13	c	1	3	2	1	1		13		
F14	p	2	14	14	13	13		14		
F15	c	2	3	2	1	1		13		
F16	c	2		2	1	1		13		
F17	c	3		2	11	12		13		
F18	c	3	11	13		1	2	13		
F19	c	4		13	11			13		
F20	c	2	3	2	1	1		13		
F21	c	3	12	13		1	1	2		
F22	p	3		1	14	14		1		
F23	p	4	13	13	12	12		3		

Value

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	2	1				13	3,2363 (Std Dev = 1,6884)	Distance-based cohesion = 0,743
F11	c	1		1	1	1		13		
F12	c	1	1	1	1	1		13		
F13	c	2	3	1	1	1		13		
F14	p	2	14	14	13	13		14		
F15	c	2	12	12		1		13		
F16	c	3	4	1	1	1		13		
F17	c	4		1		12	2	13		
F18	c	2		12	11	12	3	14		
F19	c	3	11	12				13		
F20	c	1		1	1	1		13		
F21	c	3		12		1	1	2		
F22	p	4		2	14	14		1		
F23	c	3	13	13	12	12		3		

Access

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	1	1	1	1		13	3,0385 (Std Dev = 1,6785)	Distance-based cohesion = 0,746
F11	c	2	2	1	11	1		13		
F12	c	1	1	1	1	1		13		
F13	c	1	1	1	1	1		13		
F14	p	3	14	14	13	13		14		
F15	c	2		1				13		
F16	c	1		1				13		
F17	c	2		1			2	13		
F18	c	3		12	11		3	14		
F19	c	3		12				13		
F20	c	3	3	1	1			13		
F21	c	4	12	12		1	1	2		
F22	p	2			14	14		1		
F23	p	4	13	13	12			3		

Cost

	Graph		Indices							
NODE	Central / Peripheral actors	Subgroups	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Network Density	Network Cohesion
F10	c	1	4		1	1		13	3,7527 (Std Dev = 1,8983)	Distance-based cohesion = 0,807
F11	c	1	2		1	1		13		
F12	c	1			1	1		13		
F13	c	1	1		1	1		13		
F14	p	2	14	14	13	13		14		
F15	c	2						13		
F16	p	3						13		
F17	c	3				12		13		
F18	c	4	12			1	2	13		
F19	c	2						13		
F20	c	2	3		1			13		
F21	c	4	13			1	1	2		
F22	p	3		1	14	14		1		
F23	c	3	12		12	12		3		

10.16 Appendix P: SNA - Statistic analysis of measures and indices (Numerical values) [23]

Contact

		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	9,83	0,41	0,53	0,75	1,00	0,22	1,00
	Min	0,00	0,05	0,26	0,08	0,00	0,00	0,14
	Mean	n/a	0,26	0,45	0,42	0,44	0,01	0,57
	Std.Dev.	n/a	0,12	0,08	0,24	0,44	0,04	0,27
Case B	Max	4,17	0,52	0,80	0,90	1,00	0,38	1,00
	Min	0,00	0,12	0,58	0,25	0,00	0,00	-0,33
	Mean	n/a	0,30	0,70	0,66	0,71	0,03	0,39
	Std.Dev.	n/a	0,15	0,07	0,23	0,38	0,11	0,59
Case C	Max	6,00	0,81	1,00	1,00	1,00	0,07	0,75
	Min	0,00	0,54	0,90	0,90	0,80	0,00	0,00
	Mean	n/a	0,72	0,98	0,97	0,98	0,01	0,33
	Std.Dev.	n/a	0,11	0,05	0,05	0,07	0,02	0,40
Case D	Max	5,83	0,49	0,88	0,80	1,00	0,29	1,00
	Min	0,00	0,17	0,58	0,30	0,56	0,00	-0,67
	Mean	n/a	0,32	0,72	0,56	0,74	0,06	0,35
	Std.Dev.	n/a	0,10	0,10	0,16	0,13	0,09	0,48
Case E	Max	3,33	0,50	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,19	0,61	0,38	0,00	0,00	0,67
	Mean	n/a	0,30	0,75	0,71	0,77	0,05	0,94
	Std.Dev.	n/a	0,09	0,07	0,19	0,33	0,09	0,13
Case F	Max	5,16	0,79	0,92	0,96	1,00	0,05	1,00
	Min	0,00	0,32	0,79	0,42	0,00	0,00	-0,82
	Mean	n/a	0,58	0,89	0,88	0,89	0,01	-0,27
	Std.Dev.	n/a	0,11	0,03	0,07	0,08	0,02	0,64

Get Information

		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	12,3	0,43	0,54	0,75	1,00	0,10	1,00
	Min	0,00	0,09	0,41	0,19	0,00	0,00	0,29
	Mean	n/a	0,25	0,49	0,48	0,49	0,00	0,61
	Std.Dev.	n/a	0,11	0,04	0,25	0,48	0,02	0,24
Case B	Max	4,17	0,62	0,91	0,95	1,00	0,24	1,00
	Min	0,00	0,20	0,68	0,45	0,00	0,00	-0,14
	Mean	n/a	0,39	0,82	0,80	0,83	0,02	0,45
	Std.Dev.	n/a	0,14	0,08	0,16	0,30	0,07	0,53
Case C	Max	6,00	0,73	1,00	1,00	1,00	0,18	0,75
	Min	0,00	0,46	0,90	0,67	0,62	0,00	0,00
	Mean	n/a	0,60	0,94	0,93	0,96	0,02	0,33
	Std.Dev.	n/a	0,09	0,06	0,10	0,13	0,06	0,40
Case D	Max	5,66	0,59	0,88	0,83	1,00	0,22	0,87
	Min	0,00	0,20	0,63	0,40	0,60	0,00	0,00
	Mean	n/a	0,37	0,76	0,63	0,78	0,05	0,43
	Std.Dev.	n/a	0,12	0,09	0,14	0,12	0,08	0,30
Case E	Max	3,50	0,56	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,25	0,68	0,38	0,00	0,00	0,67
	Mean	n/a	0,35	0,75	0,72	0,78	0,05	0,94
	Std.Dev.	n/a	0,10	0,06	0,20	0,34	0,09	0,13
Case F	Max	5,30	0,76	1,00	0,96	1,00	0,06	1,00
	Min	0,00	0,46	0,74	0,50	0,00	0,00	-0,54
	Mean	n/a	0,59	0,91	0,90	0,90	0,00	-0,23
	Std.Dev.	n/a	0,10	0,04	0,04	0,05	0,02	0,61

Give Information

		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	12,5	0,35	0,50	0,73	1,00	0,06	1,00
	Min	0,00	0,08	0,40	0,19	0,00	0,00	0,08
	Mean	n/a	0,24	0,46	0,45	0,46	0,00	0,61
	Std.Dev.	n/a	0,08	0,03	0,24	0,49	0,02	0,26
Case B	Max	5,17	0,67	0,91	0,95	1,00	0,27	1,00
	Min	0,00	0,18	0,68	0,45	0,00	0,00	-0,33
	Mean	n/a	0,40	0,81	0,79	0,82	0,03	0,43
	Std.Dev.	n/a	0,16	0,09	0,17	0,30	0,08	0,55
Case C	Max	5,67	0,75	1,00	1,00	1,00	0,00	0,75
	Min	0,00	0,46	1,00	1,00	1,00	0,00	0,00
	Mean	n/a	0,61	1,00	1,00	1,00	0,00	0,33
	Std.Dev.	n/a	0,11	0,00	0,00	0,00	0,00	0,40
Case D	Max	6,83	0,54	0,88	0,87	1,00	0,44	0,87
	Min	0,00	0,21	0,63	0,37	0,60	0,00	0,11
	Mean	n/a	0,36	0,77	0,66	0,79	0,04	0,47
	Std.Dev.	n/a	0,09	0,08	0,16	0,14	0,11	0,27
Case E	Max	3,50	0,50	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,23	0,68	0,38	0,00	0,00	0,67
	Mean	n/a	0,35	0,75	0,72	0,78	0,05	0,94
	Std.Dev.	n/a	0,07	0,06	0,20	0,34	0,09	0,13
Case F	Max	5,00	0,71	0,93	0,96	1,00	0,06	1,00
	Min	0,00	0,41	0,79	0,46	0,00	0,00	-0,82
	Mean	n/a	0,56	0,90	0,90	0,90	0,00	-0,25
	Std.Dev.	n/a	0,09	0,03	0,05	0,05	0,02	0,63

Knowing

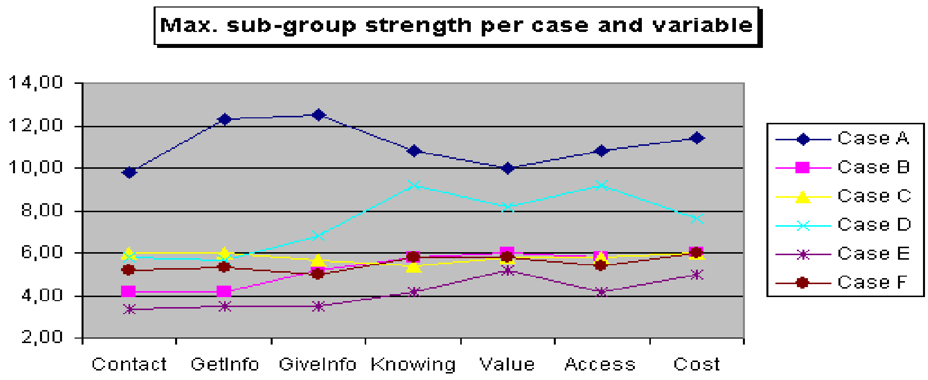
		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	10,8	0,42	0,50	0,73	1,00	0,07	1,00
	Min	0,00	0,12	0,36	0,15	0,00	0,00	0,23
	Mean	n/a	0,32	0,46	0,45	0,46	0,00	0,60
	Std.Dev.	n/a	0,08	0,04	0,24	0,48	0,01	0,25
Case B	Max	5,80	0,88	0,91	0,95	1,00	0,27	1,00
	Min	0,00	0,48	0,68	0,45	0,00	0,00	-0,33
	Mean	n/a	0,70	0,81	0,78	0,81	0,03	0,43
	Std.Dev.	n/a	0,13	0,10	0,17	0,30	0,08	0,55
Case C	Max	5,40	0,75	1,00	1,00	1,00	0,10	0,75
	Min	0,00	0,55	0,90	0,81	0,72	0,00	0,00
	Mean	n/a	0,61	0,96	0,96	0,97	0,01	0,33
	Std.Dev.	n/a	0,08	0,06	0,06	0,09	0,04	0,40
Case D	Max	9,20	0,85	0,94	0,87	1,00	0,23	1,00
	Min	0,00	0,28	0,63	0,40	0,60	0,00	-0,14
	Mean	n/a	0,56	0,77	0,64	0,78	0,04	0,44
	Std.Dev.	n/a	0,18	0,10	0,16	0,12	0,08	0,34
Case E	Max	4,20	0,75	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,48	0,68	0,38	0,00	0,00	0,67
	Mean	n/a	0,58	0,75	0,72	0,78	0,05	0,94
	Std.Dev.	n/a	0,09	0,06	0,20	0,34	0,09	0,13
Case F	Max	5,80	0,83	0,93	0,96	1,00	0,06	1,00
	Min	0,00	0,51	0,74	0,46	0,00	0,00	-0,82
	Mean	n/a	0,72	0,89	0,88	0,89	0,01	-0,25
	Std.Dev.	n/a	0,07	0,03	0,07	0,07	0,02	0,63

[23] Developed from field data using IKNOW (2003) and UCINET (2004)

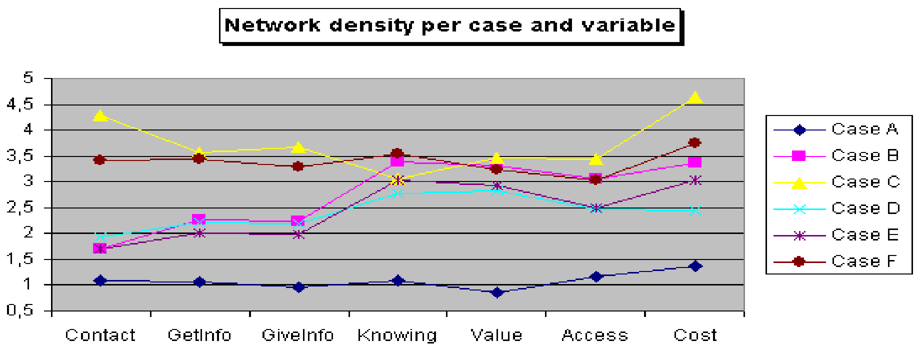
		Value							Access						
		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index	Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	10,0	0,42	0,46	0,71	1,00	0,06	1,00	10,8	0,47	0,54	0,75	1,00	0,10	1,00
	Min	0,00	0,09	0,35	0,15	0,00	0,00	0,17	0,00	0,13	0,38	0,15	0,00	0,00	0,29
	Mean	n/a	0,27	0,42	0,42	0,42	0,00	0,60	n/a	0,33	0,48	0,47	0,48	0,00	0,60
	Std.Dev.	n/a	0,09	0,03	0,24	0,48	0,02	0,27	n/a	0,11	0,05	0,25	0,48	0,02	0,25
Case B	Max	6,00	0,88	0,91	0,95	1,00	0,27	1,00	5,80	0,86	0,91	0,95	1,00	0,27	1,00
	Min	0,00	0,50	0,68	0,45	0,00	0,00	-0,33	0,00	0,40	0,68	0,45	0,00	0,00	-0,33
	Mean	n/a	0,70	0,81	0,80	0,82	0,03	0,43	n/a	0,63	0,81	0,79	0,82	0,03	0,43
	Std.Dev.	n/a	0,12	0,09	0,17	0,30	0,08	0,55	n/a	0,15	0,09	0,17	0,30	0,08	0,55
Case C	Max	5,80	0,85	1,00	1,00	1,00	0,32	0,75	5,80	0,78	0,90	0,94	1,00	0,25	0,75
	Min	0,00	0,48	0,72	0,75	0,67	0,00	0,00	0,00	0,65	0,80	0,56	0,62	0,00	-0,14
	Mean	n/a	0,70	0,90	0,88	0,91	0,04	0,33	n/a	0,68	0,87	0,85	0,90	0,04	0,29
	Std.Dev.	n/a	0,13	0,12	0,09	0,14	0,11	0,40	n/a	0,04	0,04	0,14	0,16	0,09	0,42
Case D	Max	8,20	0,84	0,88	0,87	1,00	0,24	1,00	9,20	0,69	0,88	0,87	1,00	0,25	1,00
	Min	0,00	0,29	0,60	0,40	0,56	0,00	-0,14	0,00	0,29	0,63	0,40	0,60	0,00	-0,14
	Mean	n/a	0,56	0,76	0,62	0,77	0,05	0,45	n/a	0,50	0,76	0,63	0,78	0,05	0,45
	Std.Dev.	n/a	0,18	0,10	0,16	0,12	0,08	0,34	n/a	0,14	0,09	0,16	0,13	0,08	0,34
Case E	Max	5,20	0,80	0,88	0,94	1,00	0,21	1,00	4,20	0,73	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,45	0,68	0,38	0,00	0,00	0,67	0,00	0,38	0,68	0,38	0,00	0,00	0,67
	Mean	n/a	0,61	0,75	0,72	0,78	0,05	0,94	n/a	0,52	0,75	0,72	0,78	0,05	0,94
	Std.Dev.	n/a	0,10	0,06	0,20	0,34	0,09	0,13	n/a	0,10	0,06	0,20	0,34	0,09	0,13
Case F	Max	5,80	0,82	0,92	0,96	1,00	0,10	1,00	5,40	0,74	0,92	0,96	1,00	0,12	1,00
	Min	0,00	0,51	0,74	0,42	0,00	0,00	-0,82	0,00	0,42	0,65	0,42	0,00	0,00	-0,82
	Mean	n/a	0,66	0,88	0,87	0,88	0,01	-0,27	n/a	0,62	0,88	0,86	0,70	0,01	-0,27
	Std.Dev.	n/a	0,08	0,04	0,07	0,07	0,03	0,64	n/a	0,08	0,04	0,09	0,07	0,03	0,64

		Cost						
		Subgroup Strength	Actor Simple Prestige	Actor Proximity Prestige	Actor Degree Centrality	Actor Closeness Centrality	Actor Betweenness Centrality	E-I Index
Case A	Max	11,4	0,46	0,54	0,75	1,00	0,10	1,00
	Min	0,00	0,18	0,38	0,15	0,00	0,00	0,29
	Mean	n/a	0,36	0,48	0,48	0,48	0,00	0,62
	Std.Dev.	n/a	0,08	0,25	0,25	0,48	0,02	0,24
Case B	Max	6,00	0,90	0,91	0,95	1,00	0,27	1,00
	Min	0,00	0,46	0,68	0,45	0,00	0,00	-0,33
	Mean	n/a	0,69	0,81	0,78	0,82	0,03	0,43
	Std.Dev.	n/a	0,14	0,09	0,17	0,27	0,08	0,55
Case C	Max	6,00	1,00	1,00	1,00	1,00	0,11	0,75
	Min	0,00	0,83	0,90	0,90	0,72	0,00	0,00
	Mean	n/a	0,93	0,96	0,96	0,10	0,01	0,33
	Std.Dev.	n/a	0,07	0,06	0,06	0,09	0,04	0,40
Case D	Max	7,60	0,73	0,83	0,80	1,00	0,30	1,00
	Min	0,00	0,28	0,58	0,30	0,56	0,00	-0,33
	Mean	n/a	0,50	0,71	0,54	0,73	0,06	0,38
	Std.Dev.	n/a	0,15	0,09	0,16	0,13	0,09	0,40
Case E	Max	5,00	0,80	0,88	0,94	1,00	0,21	1,00
	Min	0,00	0,48	0,68	0,38	0,00	0,00	0,67
	Mean	n/a	0,63	0,74	0,71	0,77	0,05	0,94
	Std.Dev.	n/a	0,10	0,07	0,18	0,33	0,09	0,13
Case F	Max	6,00	0,91	0,93	0,96	1,00	0,09	1,00
	Min	0,00	0,52	0,65	0,46	0,00	0,00	-0,82
	Mean	n/a	0,76	0,88	0,88	0,88	0,01	-0,25
	Std.Dev.	n/a	0,09	0,03	0,08	0,06	0,03	0,63

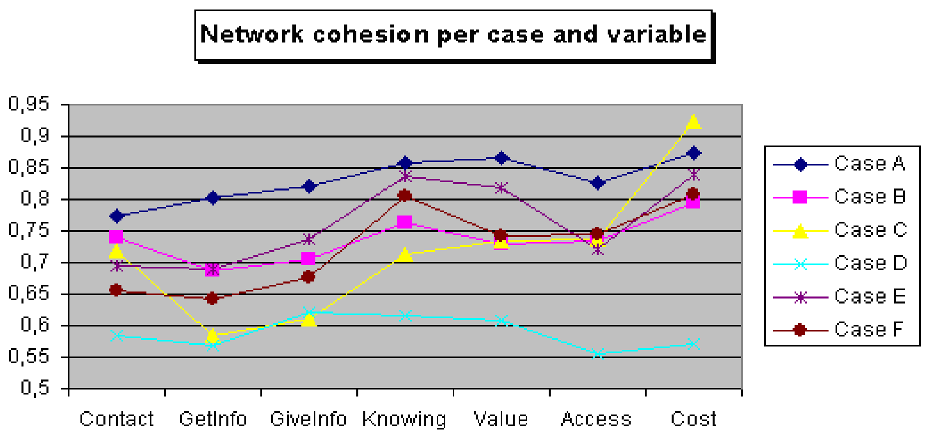
10.17 Appendix Q: SNA – Cross-case and cross-variable comparison of measures and indices (Graphical visualisation)



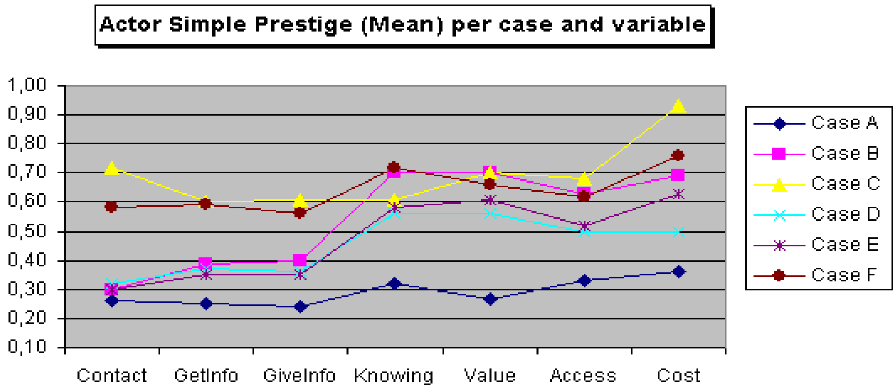
Source: Developed from field data using IKNOW (2003)



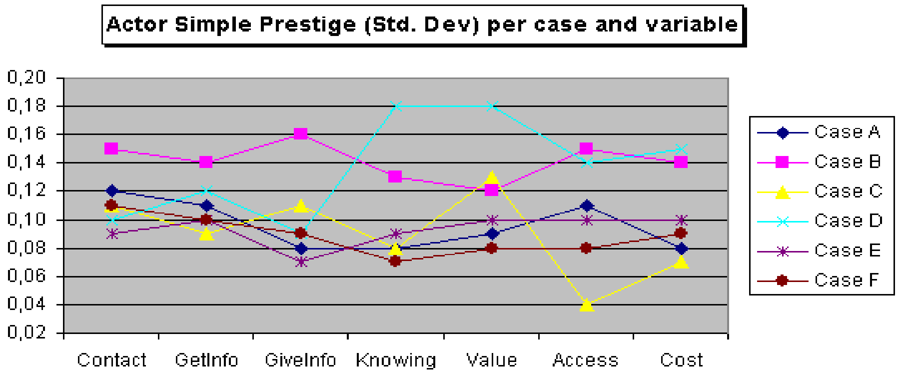
Source: Developed from field data using UCINET (2004)



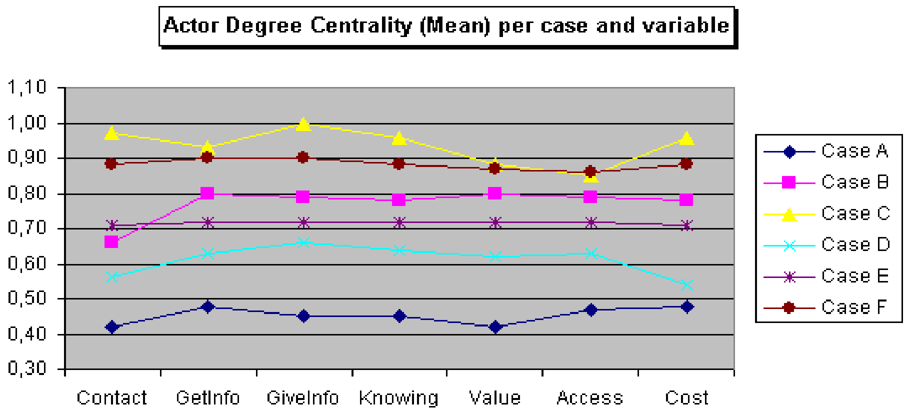
Source: Developed from field data using UCINET (2004)



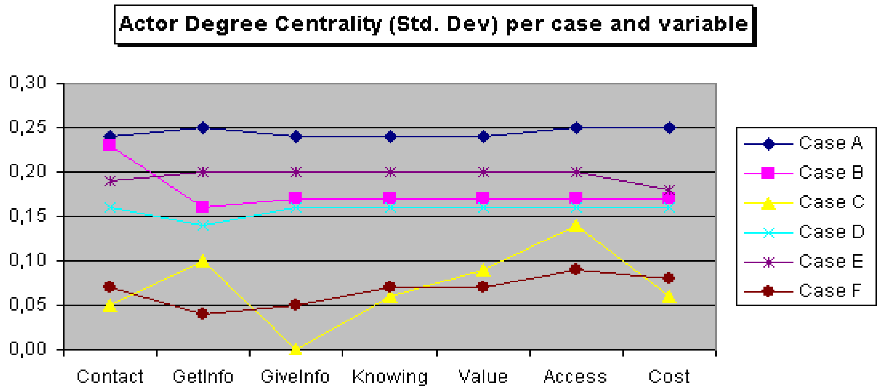
Source: Developed from field data using IKNOW (2003)



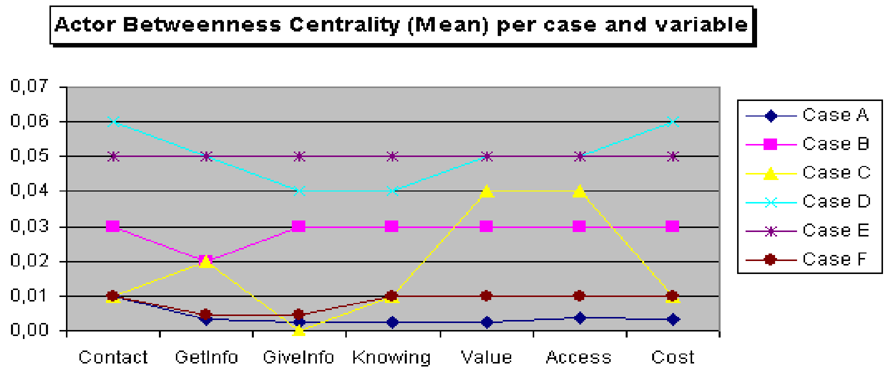
Source: Developed from field data using IKNOW (2003)



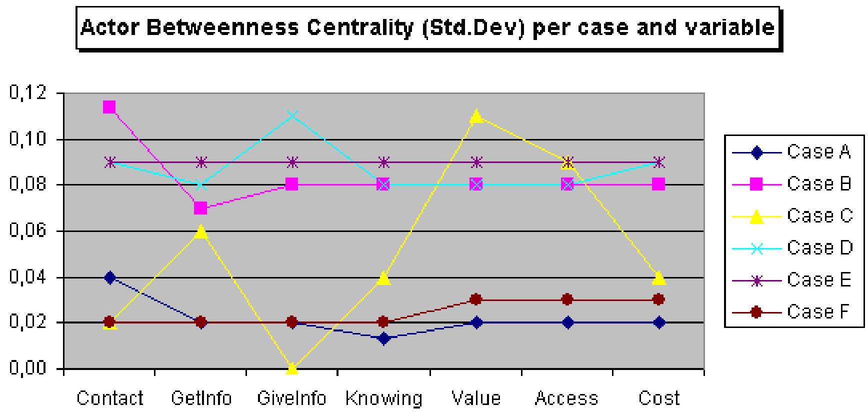
Source: Developed from field data using IKNOW (2003)



Source: Developed from field data using IKNOW (2003)



Source: Developed from field data using IKNOW (2003)



Source: Developed from field data using IKNOW (2003)