Innovating Through Knowledge Networks: A Case Study

Joanne N. Sneddon
Centre for Entrepreneurial Management & Innovation
Graduate School of Management, University of Western Australia
Email: jsneddon@gsm.uwa.edu.au

Tim Mazzarol
Centre for Entrepreneurial Management & Innovation
Graduate School of Management, University of Western Australia
Email: mazzarol@gsm.uwa.edu.au

Please tick
☑ Refereed Paper   ☐ Non-Refereed Paper

STREAM: Technology & Innovation Management

Innovating Through Knowledge Networks: A Case Study

ABSTRACT

A case study is provided that illustrates the problems associated with building a knowledge network designed to foster innovation and commercially beneficial outcomes. Despite the success of earlier networking among research groups from four separate organisations, the flow of information between these actors broke down along with the level of innovation following changes in leadership and strategic purpose. The case highlights the social nature of innovation within networks and the need for all network actors to have congruency in their strategic aims, as well as the need for networked organisations to ensure that internal systems support the external goals established for the project team.

Keywords: *Knowledge Networking; Innovation; Commercialisation; Case Study.*

THE NATURE OF KNOWLEDGE NETWORKS

Collaborative innovation is considered to be critical to the development of the scientific capabilities needed for Australia to compete in the knowledge-based global economy (Batterham, 2000; Kemp, 1999; Gigensohn, 1991). In his discussion paper "The chance for change" David Batterham, Chief Scientist (2000) emphasized the need for greater collaboration between the science base; research institutes and universities and industry in the process of innovation. Toffler (1990: 200) has described collaborative relationships that span organisational boundaries and are developed to leverage intangible, knowledge-based resources as networks that act as "informal pathways along which information can flow". Intangible knowledge-based resources are people-based therefore leveraging such resources as experience, skills and know how both within and across organisational boundaries is a social process (Trompenaars and Hampden-Turner, 1997; Palmer and Richards, 1999; Augier and Vendelo, 1999). These boundary-spanning relationships can be described as knowledge networks and are assuming an increasingly prominent role in the innovation process (Aken and Waggeman, 2000).

The relationships formed within knowledge networks determine the depth and breadth of knowledge exchange and learning between networking organisations and the overall performance of the network (Dodgson, 1996). The development of network relationships is influenced by a number of factors such as participant motivation and goals, and the culture and design of networking organisations (Jarillo, 1993). Studies of knowledge networks have focused upon the technological connectivity of network actors and how Information and Communications Technologies (ICT) can support inter-organisational communication (Savage, 1996; Swan et al., 1999). Although ICT can be used to support communication between actors and to provide access to knowledge from a diverse resource base, the effectiveness of these technologies depends upon the development of an interoperable system with a common user

interface and architecture shared between network actors (Savage, 1996; Swan et al., 1999; Ives et al, 1998). Less attention has been paid to the development of boundary spanning networks that facilitate the process of innovation through knowledge creation and transfer (Steward and Conway, 1996).

Social Exchange Theory and it application to Innovation Networks

Network analysis finds its origins in social exchange theory; although the two are conceptually different they are also closely aligned (Cook and Whitmeyer, 1992). Social exchange theory examines the social interactions that take place between individuals at what Homans (1974) termed the "elementary" level. However, social exchange can also be examined at the group or organisational level (Blau, 1964), and can include a wide range of "actors" (who can be individuals, groups or organisations) that interact within a micro and macro environmental context (Emerson, 1987). Actors within social exchange networks can be understood in terms of their self interest, and their ability to exchange items of value (e.g. goods, information). Compared to social exchange theory, network analysis remains less theoretically grounded and more empirically driven (Wellman, 1983). While social exchange theory seeks to explain why actors within a network behave the way they do, network analysis seeks to explain how these actors connect within the network.

Social exchanges between actors within a network are influenced by a range of factors including power and status differentials, attraction, integration, competition and conflict; and can be analysed from both a microstructure perspective (e.g. interactions between individuals) and a macrostructure perspective (e.g. interactions between groups or organisations) (Blau, 1964). Sociologists have sought to use such theory to better understand the dynamics of modern industrial societies (Knotterus and Guan, 1997). Social network analysis seeks to focus upon the interactions that take place within organisations, and draws upon theoretical roots in sociology, anthropology and role theory. Key elements for understanding the nature of social network analysis are: i) transactional content; ii) nature of the links; and iii) the structural characteristics. The first deals with what is being exchanged (e.g. ideas, money, goods), while the second deals with the intensity and reciprocity of the exchange, as well as the clarity of expectation between the network actors, and the level of multiplexity (e.g. how many actors are involved). The third element comprises four levels: i) external networks (how is the focal organisation linked to external actors beyond its borders?); ii) internal networks (how are the actors within the focal organisation linked to each other?); iii) Clusters within the network (areas within the network were actors are more closely linked); and iv) individuals as special nodes within the network (levels of importance for different actors) (Tichy, Tushman and Fombrun, 1979). Organisations are therefore human systems of give and take relationships in which actors or "stakeholders" are willing to give money, time or other resources (e.g. knowledge) in return for a benefit (Griesinger, 1990).

Motivations and Goals of Network Actors

The development of social relationships between knowledge network actors can enhance the process of learning (Knight, 2000; Morone and Taylor 2004). The development of such relationships can be facilitated in three key ways. First, the motivation and goals of collaborators can directly shape what will be learnt within the network (Powell, 1998). Economic theories such as transaction cost analysis, propose that collaboration is motivated by purely economic factors, with price as the sole means of cooperation. Transaction-based relationships are generally arms-length and competitive in nature (Griesinger, 1990). Knowledge networks, however, are created or emerge out of the desire of actors to learn and create new knowledge (Seufert, von Krogh and Bach,1999). Transaction based collaboration is unlikely to foster the trusting and reciprocal relationships needed to create, share and transfer tacit knowledge. Misalignment of the goals of participating organisations and actors leading to unrealistic expectations is one of the key barriers to the development of effective boundary spanning networks (Sommerville and Mroz, 1997). Knowledge network actors must communicate and work toward common goals to support a mutually beneficial innovation process (Savage, 1996; Jarillo, 1988; Lorenzoni and Baden-Fuller, 1995).

Culture and Design of Networked Organisations

A second means by which knowledge networks can be facilitated is through the culture and design of networking organisations (Hogberg and Edvinsson, 1998). Organisational culture and design play an important role in performance of knowledge networks (Senge, 1990; Chaharbaghi and Newman, 1996). The culture within a knowledge network must support entrepreneurial behaviour such as creative marshalling of resources, leadership, the creation and incubation of new ideas, risk, persistence and collaboration as core values (Holt, 1992). These entrepreneurial behaviours must be reflected in the culture of the networking organisations for the knowledge network to be able to engender innovative activities (Stein and Pinchot, 1995). The design of networking organisations will also impact on networking capabilities. For example, training and development and remuneration systems in innovative, networking organisations must be designed to reward the sharing of knowledge sharing, creation of new ideas and risk taking (Cook, 1999).

Interpersonal Relationships between Network Actors

A third means by which knowledge networks may be facilitated is through the development of appropriate interpersonal relationships between network actors (Ellison and Fundenberg, 1995). Many knowledge networks fail to meet their full potential because attention is not paid to the nature, development and maintenance of relationships. When people seek knowledge, they go to someone they know and trust making social relationships the foci of knowledge transfer (Been, 1998). To facilitate the smooth flow of

knowledge within the network, trust must be developed through frequent interactions, timely exchanges of knowledge and accurate feedback (Parkhe, 1993). Knowledge flows are commonly transferred via word of mouth in informal settings rather than more formal channels (Frenzen and Nakamoto, 1993). The strength of ties between network participants will impact upon their ability to transfer tacit and explicit knowledge (Polyani, 1957; Granovetter, 1973; Hansen, 1999). Social exchanges via interpersonal communication have been recognised as among the most important means of transferring tacit knowledge (Nonaka, 1994). Weak ties characterized by infrequent, impersonal contact are sufficient for the effective transfer of explicit knowledge. Strong network ties are developed through long-term, social relationships with face-to-face contact (Granovetter, 1983). Therefore, an *a priori* understanding of the knowledge that will be required by the network will help to determine the appropriate dynamics of network relationships (Howells and Roberts, 2000).

METHODOLOGY

In order to gain a greater understanding of the phenomena of knowledge networks between public sector research institutions a study was undertaken of a government funded research project developing remotely sensed pasture management technologies (referred to here as Pasture-Map). The Pasture-Map project brought together three public sector research organisations with a private sector enterprise: a Federal Government research agency (referred to here as CORE), a State Department of agriculture (referred to here as ARA), a State Department of land information (referred to here as SSRA) and a national agribusiness enterprise (referred to as NAO). The Pasture-Map case offers the opportunity to explore the social nature of boundary spanning, collaborative knowledge networks; and helps to identify the motivational, cultural, operational and relational factors that affected the performance of the network.

Yin (1994) suggests that case studies are a preferred research strategy when seeking to answer how and why questions are explanatory or descriptive; and that use of a single case study is appropriate where that case is critical, unique or revelatory. Case study selection should be based on the ability for the case to predict similar results (literal replication), or to predict results that are different for expected reasons (theoretical replication) (Yin, 1994). The unit of analysis in the case was the networking behaviour of the key actors within the four organisations engaged in the Pasture-Map project, and how these networks enhanced innovation and learning in the network. Triangulation was provided by securing access to a number of data points within each organisation, and by verifying the interviews from network members with data collected from other members of the network and secondary sources (Patton, 1987). The methodology was "grounded" in its approach with the researchers embedded within the network and dealing on a daily basis with many of the actors for a period of just over six months. While not strictly a

grounded theory methodology (Glaser and Strauss, 1967), such an approach can be very useful when seeking to study human behaviour (Goulding, 1998).

This research study was undertaken in three phases. During the first phase a series of informal and unstructured interviews were conducted with research scientists, project leaders and program managers from the four networking organisations to identify their motivations and goals, network actors and project goals. Secondly, focus group interviews were undertaken out as part of a project feasibility study to test the needs and desires of the potential target market for Pasture-Map and to gain an understanding of how the knowledge network would need to evolve to realize the commercial potential of Pasture-Map. Thirdly, the development of the Pasture-Map technology by the four organisations was observed over a six-month period and a review of relevant documentation relating to the project was conducted to explore the culture and design of the CORE organisation and the nature of network relationships between actors. The study focused on three prominent dimensions of knowledge network development and management; 1) motivation and goals, 2) networking attributes and 3) network relationships. These dimensions were selected because each has been positively linked in the extant literature to effective knowledge network performance such as the expedient delivery of new products to market. A single case study methodology was employed to examine these key influences on performance. The remainder of this paper is structured in three parts. In the first part a description is provided of the creation, motivation and goals of the knowledge network actors and important milestones in the project are highlighted. A discussion of the internal culture and design of the CORE organisation identifying the underlying attributes determining the networking capabilities of collaborators follow this. Finally, the nature of network relationships is discussed along with the implications for creating and managing effective knowledge networks.

PHASE ONE – RESEARCHING PASTURE-MAP TECHNOLOGIES

While knowledge networks can take many different forms, the focus of this study was a loose, non-contractual collaboration between three research institutions and one private enterprise. The CORE organisation funded and coordinated the basic research for Pasture-Map with equity in the project secured by ARA and SSRA through in-kind contributions of labour, knowledge and data. The main objective of the network was to develop a web-based pasture management system that would enable Australian graziers to improve pasture utilisation. At the time of writing, Pasture-Map has failed to secure further funding for product development and market testing.

The CORE team developed networks with ARA and SSRA in 1996 to combine knowledge, experience and data from a range of sources with the explicit objective of developing methodologies to measure

pasture growth and quantity using satellite or remotely sensed data (Pasture-Map). The project leader of the CORE team had extensive professional and social networks in the field of Mediterranean agronomy and remote sensing technologies. Strong interpersonal relationships between the CORE team project leader, ARA program manager and SSRA program manager thus created an opportunity for sharing, creating and transferring knowledge to develop the Pasture-Map project. These key actors from the three public sector research organisations had previously worked together on similar research projects in the field of agronomy and remote sensing and shared a strong drive to create new technologies in this field. The CORE and ARA project teams shared the goal of increasing the sustainability of the Australian grazing industries. The SSRA's key organisational objective was to add-value to remotely sensed and spatial data by developing practical applications for industry. Therefore strong personal ties between key actors at the networking organisations and mutuality of motivation and goals helped the development of close interpersonal relationships.

The CORE project team wanted to explore, develop and test new pasture measurement technologies as a means of providing graziers with greater efficiency opportunities in their grazing enterprise. This research concept had been developed by the CORE organisation independently of the other network actors, however, the CORE team required agronomic and remotely sensed data, support and expertise to realise their research goals. In the initial phase of the Pasture-Map research project the knowledge network proceeded on an informal basis. The ARA project team produced a letter of intent in response to the CORE team's research proposal, agreeing to supply data and technical support during the research phase of the project. The SSRA supplied remotely sensed data at no cost to the CORE team through a verbal agreement between the CORE project leader and SSRA program manager.

The informal nature of network relationships during the initial research phase along with complementary motivations and goals aided the smooth flow of information between actors. The initial research phase of the project took four years to complete; during this period remotely sensed data and agronomic information was transferred from the ARA and SSRA project teams to the CORE team who used this data to develop and test pasture measurement technologies. Feedback from the CORE team on the progress of the project was limited to quarterly briefings with the ARA team and infrequent, transaction based contact with the SSRA team. Although the trusting nature of the relationships did not change throughout this stage the failure to maintain close and frequent contact meant that the network did not respond effectively to changes in key personnel during the development phase of the project. The three key project champions within the CORE team, ARA and SSRA left their jobs at the end of the Pasture-Map research phase. The project leader's position in the CORE team was filled with a research scientist with a background of agronomic research. However, researchers who did not share their predecessor's

knowledge, experience and enthusiasm of the project filled the project team leader positions at the ARA and SSRA, leaving the CORE team without the strong interpersonal relationships required to move Pasture-Map into the development phase.

PHASE TWO – DEVELOPING AND TESTING PASTURE-MAP

The development phase of Pasture-Map began in 2000 when the CORE team instructed researchers from a local university to carry out a commercial feasibility study. The Pasture-Map concept had not been tested with the potential target market, Australian graziers during the research phase. Therefore, the network actors had little understanding of the felt need for remotely sensed pasture management technologies within its target market. The feasibility study of Pasture-Map tested the preferences of a sample of Australian graziers in relation to delivery of Pasture-Map technologies through focus group interviews and surveys. The market research undertaken during the feasibility study highlighted the resources required and activities to be undertaken by network actors in order for Pasture-Map to be commercialised. The target market expressed a preference for a delivery system that provided not only pasture measurements, but a broad range of interpreted information related to crop performance, and land care. To deliver these diverse resources to Australian graziers the network would have to be expanded to include other public and private enterprises developing farming and land management technologies.

During the Pasture-Map development phase, the CORE team was approached by a large agribusiness organisation, NAO. The NAO expressed an interest in licensing Pasture-Map for commercial delivery as they felt that this technology had the potential to complement similar product offerings developed by them for the cropping market. The development of a product based on remotely sensed technologies delivering both pasture and crop management information would provide the NAO with considerable competitive advantage within the agribusiness sector. The CORE project team did not invite ARA and SSRA to join these discussions with NAO as they felt that they owned the Intellectual Property (IP) associated with Pasture-Map.

The CORE team was keen to bring commercial partners such as the NAO on board to share risk and gain access to market. After initial discussions with the NAO regarding further research funding and commercialisation of Pasture-Map, the CORE team sought an agreement with NAO that would provide access to Pasture-Map but protect CORE's IP. NAO, however, wanted to continue discussions on an informal basis to probe the market feasibility of Pasture-Map without committing to future development. In effect the NAO required full access to a market-tested product, to reduce any potential investment

exposure. Negotiations offered little room for developing a spirit of reciprocity and trust required for ongoing collaboration and an agreement could not be reached between the two parties.

Pasture-Map Pilot Study

A major hurdle in the development stage of the Pasture-Map project was the change of key personal within the knowledge network that left the CORE team without access to data required to set up an initial pilot study. The CORE team planned to test pilot Pasture-Map with seven graziers in the south west of Western Australia. The graziers selected for the pilot study were working with the ARA on a separate research project providing established lines of communication and a means of data delivery for the CORE team. However the loss of Pasture-Map project champions at the ARA and the SSRA and subsequent failure of the CORE to team to maintain interpersonal relationships within the network proved to be a disaster. The CORE team were unable to access critical data needed to set up the pilot study such as farm boundary information and paddock soil types. Without project champions in the ARA and SSRA, these resources proved to be virtually impossible to access. For example, the ARA held farm boundary information in a separate department to the ARA agronomic researchers who did not have either close ties or an agreement in place with the CORE team. The SSRA were able to provide satellite imagery for the study, but not on a timely basis as processing data for Pasture-Map was not a priority for the management team. Therefore, pasture data for the pilot study farms were several weeks out of date before they could be delivered. Problems accessing network resources during the pilot phase highlighted the need for network relationships to be maintained and developed with future knowledge resource requirements in mind.

Another barrier to the development of Pasture-Map was discovered during the development of the pilot study in the shape of incompatibility of ICT systems of the network organisations. The CORE team intended to deliver Pasture-Map to farmers via the Internet. Pasture-Map would combine farm data from the SSRA, soil and agronomic data from the ARA and measurement models from the CORE team interpreted and delivered to the farm gate electronically. Up until the pilot study, this data had been transferred to the CORE team after considerable manual processing and the issue of ICT compatibility had not arisen. However, when setting up the pilot study the CORE team found that their Geographic Information System (GIS) was incompatible with the ARA's GIS and could not transfer data automatically between the two organisations, adding to the cost and resources required to process the data.

REALISING THE POTENTIAL OF PASTURE-MAP

In May 2000 the CORE team formally launched the Pasture-Map model to stakeholders in government agencies, the grazing industry and agribusiness sector. The CORE organisation acted as project leaders as they had made the greatest investment or resources in Pasture-Map to date. The research phase of the project was characterized by informality of network relationships, congruity of goals and reciprocity between knowledge network participants. The focus of the network in the development phase began to shift towards formal agreements over IP and funding and the development of a more structured approach to cross-boundary communication.

Characteristics of Networking Organisations – the CORE Organisation

The CORE organisation recognised the importance of collaborating with public and private enterprise to realise their research goals and encouraged its research staff to be highly collaborative. As a research institution, the design and culture of the CORE organisation supported the systematic and non-time bound pursuit of knowledge. During the research and development phases of the Pasture-Map project the CORE organisation underwent a major strategic shift from a "public good" orientated research agency with a "publish or perish" philosophy, to a research institution competing for funds and becoming increasingly focused upon investing in research and development that would add economic value to the national economy. This strategic and cultural shift was difficult for the long-standing members of the CORE team to adjust to as their research in the past had been considered to be complete with publication rather than commercialisation.

The CORE organisation has always fostered idea sharing within and outside of organisational boundaries. Both formal and informal forums for knowledge exchange exist within the CORE organisation, the most informal forum being the morning and afternoon tea breaks. These regular, informal gatherings of researchers were highly valued by the CORE project team as they provided an opportunity to learn about industry issues and the progress of a range of projects. However, many researchers felt that it was becoming increasingly difficult to maintain a presence at these informal and open gatherings due to increasing workloads and a greater emphasis on commercialisation. Members of the CORE project team travelled to conferences as often as research budgets would allow in order to maintain relationships with the broader scientific community. Collaborative research entities such as Cooperative Research Council's (CRC) also provided opportunities for researchers in the CORE organisation to network. However, few of these boundary-spanning activities created opportunities to develop relationships with commercial partners.

The CORE organisation employs highly qualified and motivated scientific researchers committed to the pursuit of new knowledge in various fields of endeavour. The CORE teams project leader motivated team members by creating an atmosphere of trust, respect and creativity. Members of the CORE team treated their work as a cause rather than a job as one member of the team explained: *"when you are working on a project you focus on it all of the time, you don't think about anything else"*. The language used by the CORE team was reflected the culture of the organisation. Team members discussed the Pasture-Map project using highly scientific, project specific terminology that had developed by the CORE team over time. The language of the Pasture-Map project was difficult for those outside of the CORE team to understand and the team found it difficult to discuss Pasture-Map concepts with the uninitiated.

Motivation to Network

Forming networks with key industry players is considered by many researchers to be critical for successful innovation. However, the training, development and remuneration systems of the CORE organisation did little to highlight the importance of social relationships needed to support such collaboration. Performance appraisal systems for example measured individual rather than team performance. A key performance criterion for researchers at the CORE organisation was their ability to attract external funding to their projects. Although the ability and opportunity to develop networks is not developed internally or resourced by project budgets there is a widely held belief among research scientists that they must have well-developed industry networks in order to progress within the CORE organisation.

The CORE organisation's IP arrangement is complete ownership of any IP generated by employees during the course of their employment at the organisation. Researchers are not currently rewarded financially or otherwise for the successful commercialisation of their inventions. However a recent internal study found that rewards in the form of royalties or a stake in project equity would prove to be a great incentive for innovation and collaboration. Rank and salary at the CORE organisation depends upon length of service, qualifications and success in meeting individual performance criteria. The compensation structure is highly individualistic, encouraging commitment to employee's individual accomplishments rather than those of the project team.

External Relationships

The Pasture-Map knowledge network was facilitated largely by interpersonal relationships between the CORE team and their network partners. The project leader of the CORE team had a long-standing professional and social relationship with researchers at the ARA. It was this relationship that instigated collaboration on the Pasture-Map project. The trusting nature of this relationship was reflected in the

informality of the letter of intent from the ARA laying out guidelines for the transfer of knowledge and information to the CORE team.

During initial discussions between the two parties, concepts for new pasture technologies were discussed. Tacit knowledge was shared and transferred between the participants in terms of gaining an in depth understanding of how each party operated and their potential input into the research project. However, after these initial discussions only explicit knowledge was transferred between the partners in terms of pasture research findings. As this knowledge was transferred electronically there was no clear need to maintain the social relationships fully and contact was reduced to quarterly progress reports.

The relationship between the CORE team and the SSRA team was also founded on mutual respect born out of the research scientist's long-standing, professional and social relationships. Trust between the CORE team and the SSRA enabled the partners to share and transfer knowledge and data without formal agreements. After initial discussions about the proposed research project and verbal agreements as to the role of the SSRA within the network, remotely sensed data was transferred to the CORE team electronically. Regular interpersonal contact however, was not a feature of this network relationship throughout the research phase of the Pasture-Map project.

DISCUSSION OF FINDINGS

The case demonstrates that in knowledge networks, motivation and goals matter: network participants need to have common networking intent and congruity of goals to achieve mutually beneficial outcomes. Powell's (1998) argument that the motivational factors for collaboration can directly shape what is learnt by collaborators is evident in this study. In the research phase of the Pasture-Map project network participants were motivated to create, share and transfer knowledge. Shared motivation supported the informal nature of the knowledge network. However, the motivations and goals of collaborators during the development phase of the project were not discussed or agreed by the network participants. The absence of agreed mutual goals replaced network reciprocity with secrecy, as collaborators become more concerned with securing their share of IP and project equity. Network relationships at the development phase of Pasture-Map became more formal and transaction based. Ongoing attention must be given to the motivations and short, medium and long-term goals of network participants to ensure that mutuality is retained and that the network can evolve effectively. Failure to manage the mission of the network may lead to mistrust and impede the development of social relationships between participants.

Transactional Content and Linkage Relationships

The knowledge network created by the CORE organisation as a result of the Pasture-Map project involved the transfer of a complex range of tacit and explicit knowledge. In addition to the transfer of data and formally structured reports (explicit knowledge), there were substantial and significant exchanges of tacit knowledge via word of mouth through a combination of formal and informal associations. In knowledge networks a shared system of meaning is required to facilitate communication, knowledge creation, sharing and transfer (Trompenaars et al., 1997). Although knowledge networks such as in the Pasture-Map project case can be made up of heterogeneous participants with limited shared meaning it is critical that participating organisations have a culture that supports boundary-spanning networking activities. Collaborative organisations such as the CORE organisation in the case study make networking a central value embedding it into organisation culture. However, as discussed in the case, collaborative innovation is supported by CORE organisation culture, but not by organisational design in terms of performance criteria, reward structure, and training and development. The intellectual property policy of the CORE organisation prevented researchers from benefiting from the commercialisation of their projects. Rewards were based on individual rather than team performance and training was not put in place to develop researchers networking and commercialisation skills. The strong interpersonal relationships that initially existed between the project team leaders from CORE, ARA and SSRA were critically important in the establishment of the Pasture-Map project. Linkage relationships between these individuals (who formed key nodes within the network) were characterised by intensity, reciprocity, clarity of expectation and high levels of multiplexity. Each project team leader possessed their own strong professional network within their respective field of expertise. This leadership was therefore important to the effectiveness of the networking and was adversely affected when the team leadership changed within the CORE organisation.

Structural Characteristics

As outlined in the case the CORE organisation was engaged with ARA and SSRA, as well as with NAO. The multi-disciplinary nature of the Pasture-Map project forced a high degree of external networking between these organisations. In turn, the project required each organisational actor to draw upon additional network relationships in order to move the research work forward. The importance of the team leaders has been noted and the case highlighted the need for each network participant to enjoy high levels of tie-strength (intensity), reciprocity, clarity of expectation and role congruency. A key issue was the compatibility of the organisational cultures of the respective network organisational actors.

In order to align organisation design with networking values organisations must design their remuneration systems to reward collaboration through team performance reviews and incentives for knowledge sharing. A more magnanimous attitude towards intellectual property is also required to offer incentives for

innovation by sharing the proceeds of commercialisation with research teams. Employees of networking organisations require training and development that will enable them to function within a collaborative work environment. Knowledge networks are formed to generate new knowledge or to innovate. Innovation and collaboration requires freedom for employees to make appropriate decisions, develop mutually beneficial relationships and take risks. The culture of the CORE organisation in the case study encouraged the systematic pursuit of knowledge without the financial risks associated with commercial enterprise. This culture had been shaped by a management strategy of employee empowerment, governance by trust and the recruitment and selection of highly motivated employees. For networking and innovation to remain core values of an organisation an ongoing level of support from management is required. Therefore managers must retain a balance between control and creativity depending on the skills and experience of their network team and the stage of the innovation process.

The ICT systems of knowledge network participants must enable effective and timely communication and knowledge transfer. Savage (1996) argues that this can only occur through technical compatibility between participants. This argument is supported by the case study where technical incompatibility has been a major constraint in the innovation process. In order to avoid such difficulties compatibility of participant infrastructure should be determined at the creation of the network. Addressing technical issues at the start of the innovation process will help network participants to identify potential knowledge resources for the project and development of a clear communications strategy.

Network Participant Relationships

To achieve knowledge network goals cooperative social relationships must be developed between participants. The literature and the case study suggests that social relationships based on trust and reciprocity are the most effective way of facilitating sharing, creation and transfer of knowledge within networks (Hutt et al., 2000; Palmer et al., 1999; Swan et al., 1999). Trust based relationships reduce the need for formal agreements. Network participants in the case were initially approached because they were known and trusted by the CORE team. This element of trust was reflected in the openness and informality of arrangements regarding knowledge transfer. Without close, cooperative relationships between network participants to enable the development of a shared system of meaning, knowledge transfer will be impeded.

The Evolution of Network Relationships

Critical interpersonal links within knowledge networks can be broken as participants change over time. In the case study, the turnover of key staff levied a heavy toll on the performance of the knowledge network because it removed project champions from the network. These key personnel had strong

interpersonal relationships on which the knowledge network was founded. Loss of these connections had the greatest impact during the pilot study project as it became virtually impossible to access critical knowledge resources from the network partners without collaborators within the network organisations. New relationships were not developed within the network organisations to facilitate the smooth access to these resources.   The development of relationships between network participants must be properly resourced by the networking organisations. Frequent communication and team-building exercises may be necessary to build the social fabric of relationships if tacit knowledge is to be transferred.   The appointment of a member of the knowledge network to act as a network manager may also be required to develop and maintain critical relationships.

The Strength of Network Relationships

The strength of ties between network participants is directly linked to effectiveness of knowledge transfer (Hansen, 1999).   Therefore it is critical for network participants to have an understanding of the knowledge resources that they may require from one another in order to develop the types of relationships needed to facilitate effective knowledge transfer. In the case study close ties were not maintained with network participants after the creation of the network because the knowledge to be transferred was codified, requiring little interpretation.   Tacit knowledge transfer requires strong ties and explicit knowledge transfer requires weak ties. Participants can determine the strength of relationship ties required in a knowledge network by identifying the type of knowledge to be transferred.

CONCLUSIONS

Organisations such as the CORE collaborate in knowledge networks on research projects because they do not have the tangible and intangible resources to carryout research, development and commercialisation on their own. Knowledge networks can be formed to facilitate learning and the transfer of knowledge. However, as the end goal of such networks is often to produce a commercially viable entity, knowledge networks can be very heterogeneous groups. They bring together participants with a range of motivations, goals, cultures and structures to develop potentially valuable IP. Effective management of these networks requires development of relationships that yield knowledge and learning yet protect the IP, skills and knowledge base of the network partners.

In our study the CORE organisation used a highly centralized approach to communication and knowledge exchange largely by being the instigators and major funding agencies of the project and taking ownership of the research and development process at an early stage. However changes in key project personnel during the development phase of the project left a network consisting of disparate contacts accessed for

specific data rather than as co-ordination points with mutual goals and understanding. This disparate approach to communication caused some blockages in the project in terms of accessing information for the pilot study and all collaborators giving different levels of priority to the project. Information flow slowed because strong ties between network actors had not been maintained during the course of the invention stage of the project. Therefore difficulties in understanding occurred during the development stage as the project team had not evolved from transaction based relationships to ones that could facilitate knowledge exchange and learning. In terms of information required for the pilot study, network actors lacked the authority and internal relationships to access data and establish the project as a priority in their own organisations. This became a frustration for the CORE organisation that sought multiple alternative routes within the network to access the information they required. Such issues slowed down the research project considerably and may have created suspicion with the network organisations of the CORE team seeking to access ARA and SSRA IP. Leading to the desire for collaborators to have greater protection of their intellectual assets or the request for the CORE organisation to pay market rate for what had been 'in kind' contributions in the past.

In developing an innovative knowledge network collaborators must select project champions or knowledge coordinators within each networking organisation. The network must seek the support of senior management to empower them to access relevant knowledge and expertise as they see fit. Mutuality and understanding of goals and motivation to share knowledge must be openly discussed and agreed upon by all network participants. Network participants must be selected for their ability and willingness to share knowledge, experience and expertise in a relatively open forum. However, ongoing attention must be paid to IP issues to ensure that all parties feel protected without formalizing relationships to the point that they cannot share knowledge freely. Trust and reciprocity are critical and must be maintained throughout the life of the network. Organisations participating in knowledge networks should analyse their culture, strategy and design and ensure that they support both the ethos and the reality of knowledge networking. Knowledge networks require not only the right strategic intent to succeed but also the ability to develop trust-based relationships that will facilitate knowledge exchange and learning.

This case demonstrates that building and maintaining strong relationships between network participants underpins mutuality of goals, motivation, and the amount and quality of knowledge exchanged. Other issues such as cultural compatibility and ICT interoperability of participating organisations are critical in the development of successful knowledge networks. A boundary-spanning web of relationships within the knowledge network will facilitate the flow of information, knowledge, learning, strategies and motivation. Nurturing those relationships through network champions, ICT, culture, structure and internal strategy will

help to build trust and pre-empt developments required to support future knowledge requirements. Hence network relationships will be able to evolve in advance of innovation process need.

REFERENCES

Aken, J. E. v. & Weggeman, M. (2000). Managing learning in informal innovation networks: Overcoming the Daphne-dilemma. *R&D Management*, **30**(2): 139-149.

Augier, M. & Vendelo, T. M. (1999). Networks, cognition and management of tacit knowledge. Journal of *Knowledge Management*, **3**(4): 252-261.

Batterham, D. (2000). *The Chance to Change*. Canberra, ACT: Office of the Chief Scientist.

Blau, P. M. (1964). *Exchange and Power in Social Life*. New York, J. Wiley.

Chaharbaghi, K., and Newman, V. (1996). "Innovating: Towards an integrated learning model." *Management Decision* **34**(4): 5-13.

Cook, P. (1999). "I heard it through the grapevine: making knowledge management work by learning to share knowledge, skills and experience." *Industrial and Commercial Training* **31**(3): 101-105.

Cook, K. S., and Whitmeyer, J.M. (1992). "Two Approaches to Social Structure: Exchange Theory and Network Analysis." *Annual Review of Sociology* **18**: 109-127.

Dodgson, M. (1996). Learning, Trust and Inter-Firm Technological Linkages: Some Theoretical Associations. *Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation*. R. Coombs, Richards, A., Saviotti, P. and Walsh, V. Cheltenham, Edward Elgar**:** 54-75.

Ellison, G., and Fudenberg, D. (1995). "Word of Mouth Communication and Social Learning." *The Quarterly Journal of Economics* **110**(1): 93-125.

Emerson, R. M. (1987). *Social Exchange Theory*. Beverly Hills, CA, Sage.

Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago, C.A., Aldine.

Goulding, C. (1998). "Grounded Theory: the missing methodology on the interpretivist agenda." *Qualitative Market Research* **1**(1): 50-57.

Granovetter, M. (1973). "The Strength of Weak Ties." *American Journal of Sociology* **78**(6): 1360-1380.

Granovetter, M. (1983). "The Strength of Weak Ties: A Network Theory Revisited." *Sociological Theory* **1**: 203-233.

Griesigner, D. W. (1990). "The Human Side of Economic Organization." *The Academy of Management Review* **15**(3): 478-499.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization sub-units. *Administrative Science Quarterly*, **44**(1): 82-111.

Hogberg, C., and Edvinsson, L. (1998). "A Design for Futurizing Knowledge Networking." *Journal of Knowledge Management* **2**(2): 81-92.

Holt, K. (1992). Creative problem solving and generating product ideas. In G. Salvendy (Ed.), *Handbook of Industrial Engineering*. New York: Wiley.

Homans, G. C. (1974). *Social Behavior: its elementary forms*. New York, Harcourt Brace Jovanovich.

Howells, J., and Roberts, J. (2000). "From Innovation Systems to Knowledge Systems." *Prometheus* **18**(17-31).

Jarillo, J. C. (1993). *Strategic Networks: Creating the Borderless Organization*. Oxford, Butterworth-Heinemann.

Jarillo, J. C. (1988). "On Strategic Networks." *Strategic Management Journal* **9**(1): 31-41.

Kemp, D. (1999). *Knowledge and Innovation*. Canberra, ACT: Department of Education, Science and Training.

Knight, L. A. (2000). "Learning to Collaborate: A Study of Individual and Organizational Learning, and Interorganizational Reltationships." *Journal of Strategic Marketing* **8**(2): 121-138.

Lorenzoni, G., & Baden-Fuller, C. (1995). "Creating a Strategic Centre to Manage a Web of Partners." *California Management Review* **37**(3): 146-166.

Morone, P., and Taylor, R. (2004). "Knowledge Diffusion Dynamics and Network Properties of Face-to-Face Interactions." *Journal of Evolutionary Economics* **14**(3): 327-351.

Nonaka, I. (1994). "A Dynamic Theory of Organizational Knowledge Creation." *Organizational Science* **5**(1): 14-37.

Palmer, J. & Richards, I. (2000). Get knetted: Network behaviour in the new economy. *Journal of Knowledge Management*, **3**(3): 191-202.

Patton, M. Q. (1987) *How to Use Qualitative Methods in Evaluation*, Sage, Newbury Park, CA

Parkhe, A. (1993). Strategic alliance structuring: A game theoretic and transaction cost examination of interfirm cooperation. *Academy of Management Journal*, **36**(August): 794-829.

Polanyi, K. (1957). *The Great Transformation*. Boston, Beacon Press.

Powell, W. W. (1998). Learning from collaboration: Knowledge networks in the Biotechnology and Pharmaceutical Industries. *California Management Review*, **40**: 228-240.

Savage, C. M. (1996). *5th Generation management: Co-creating through virtual enterprising dynamics, teaming and knowledge networking*. New York: Butterworth-Heinemann.

Senge, P. (1990). *The Fifth Discipline: The art and practice of the learning organization*. Sydney, Random House Australia.

Seufert, A., Krogh, H. v., & Back, A. (1999). Towards knowledge networking. *Journal of Knowledge Management*, **3**(3): 180.

Somerville, I. & Mroz, J. E. (1997). New competencies for a new world. In Hesselbein & Godsmith & Beckhard (Eds.), *The organization of the future*. San Fransisco: Jossey-Bass.

Stein, R. G., and Pinchot, Gifford (1995). "Building an intelligent organization." *Association Management* **47**(11): 32-43.

Steward, F., & Conway, S. (1996). Informal Networks in the Origination of Successful Innovations. *Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation*. R. Coombs, Richards, A., Saviotti, P. and Walsh, V. Cheltenham, UK, Edward Elgar**:** 201-222.

Swan, J., Newell, S., Scarborough, H., & Hislop, D. (1999). "Knowledge Management and Innovation: Networks and Networking." *Journal of Knowledge Management* **3**(4): 262-275.

Tichy, N. M., Tushman, M.L., and Fombrun, C. (1979). "Social Network Analysis for Organizations." *Academy of Management Review* **4**(4): 507-519.

Toffler, A. & Toffler, H. (1990). *Powershift*. New york: Bantam.

Presented to ANZAM Conference 2005, 8-11 December, Canberra.

Trompenaars, F. & Hampden-Turner, C. (1997). *Riding the waves of culture: Understanding cultural diversity in business*. London: Nicholas Brealey.

Wellman, B. (1983). "Network Analysis: Some Basic Principles." *Sociological Theory* **1**(6): 155-200.

Yin, R. K. (1994). *Case Study Research: Design and Methods*. London, Sage Publications.