THE INFLUENCE OF SOCIAL NETWORKS ON KNOWLEDGE MANAGEMENT FOR INNOVATION IN LIFE-SCIENCE DISCOVERY NETWORKS

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Keywords: Innovation, Social Networks, Knowledge Management.

Abstract: The competitiveness and sustainability of a modern organisation depends on its ability to innovate. It is increasingly accepted that knowledge, skills and competencies are the key drivers of innovation. Access to the latest information can provide critical competitive edge for organisations' innovation efforts. Social networks are found to promote organisational and collective learning and are a significant source of knowledge which subsequently leads to innovation. The paper aims to introduce social network analysis as a useful methodology for organisations and managers to use to analyse how collaboration for knowledge management for innovation efforts is accomplished. Social network analysis (SNA) facilitates analysis of relationships among actors in a network. It describes a number of social network factors that are useful in analysing overall network structures, network content, the characteristics of interactions and identifying the impact they have on knowledge management for innovation efforts. This will illuminate the mechanisms through which collaboration for innovation is accomplished. Three case studies of a knowledge network within the life sciences sector are utilised to conduct an exploration into how knowledge is managed through social networks for innovation.

1 INTRODUCTION

One useful view of innovation is that it is the combined activity of generating creative ideas (i.e. new knowledge) and the subsequent successful exploitation of these for benefit (Roberts, 1988; von Stamm, 2003; O'Sullivan and Dooley, 2008). Creativity results in the development of new knowledge and learning. Creativity may be viewed as the combination of existing knowledge into new and useful concepts to satisfy a need (Farid-Foad et al., 1993). The exploitation of value from the realisation of these novel ideas is the output of the innovation process.

The paper aims to introduce social network analysis as a useful and effective methodology for organisations and managers to use to analyse how cooperation and collaboration for knowledge management for innovation efforts is accomplished. Social network analysis (SNA) facilitates analysis of relationships among actors in a network. It describes a number of social network factors that are useful in analysing overall network structures, network content, the characteristics of interactions and identifying the impact they have on knowledge management for innovation efforts. This will illuminate the mechanisms through which cooperation and collaboration for innovation is accomplished. Three case studies of a knowledge network within the life sciences sector is utilised to conduct an initial exploration of how knowledge is managed through social networks for innovation. The paper will explore key stages of a knowledge management for innovation process from the social network perspective.

2 KNOWLEDGE MANAGEMENT FOR INNOVATION

For an organisation to successfully innovate i.e. to optimize the way new knowledge is developed and existing knowledge is exploited, it needs to facilitate the dynamic capabilities required for converting the knowledge available from the insights and competences of individual people (the source of new knowledge) into appropriate structures, processes,

Gubbins C. and Dooley L..
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DOI: 10.5220/0003075001820188
In *Proceedings of the International Conference on Knowledge Management and Information Sharing* (KMIS-2010), pages 182-188
ISBN: 978-989-8425-30-0

products and systems that allow the value, in this case innovation, to be exploited (McKenzie & van Winkelen, 2004). Current perspectives of the innovation process view it as an interactive and networked system that spans organisational boundaries to draw on knowledge, experience and capabilities from diverse sources to achieve development objectives (Rothwell, 1992; Tidd et al, 2005). Moves in this direction include organisations moving from functionally based formal structures to matrix, team-based and networked structures (Morton et al., 2006). Such organizations are 'highly adaptive entities that transcend traditional boundaries as they develop deep and collaborative relationship internally as well as with customers, suppliers, alliance partners and increasingly competitors' (Neilson et al., 2004). It is argued that these relationship-driven organizations are more successful than their non relationship-driven counterparts (Morton et al., 2006).

The social network perspective is an appropriate lens through which to examine the interactions among employees (both within and outside the firm) that enable collaborative work to be accomplished (Cross & Parker, 2004), or in this case, that enable learning, knowledge access, transfer, absorption and accumulation for the purposes of innovation. It enables exploration of how collaborative social networks facilitate knowledge management for innovation. A social network perspective permits conceptualizing the whole, rather than the parts (Storberg & Gubbins, 2007. A social network is a set of people or groups, called 'actors', with some pattern of interaction or 'ties' between them.

2.1 Understanding the Knowledge Management Phases

Innovation is about creating new possibilities through combining different knowledge sets. Such knowledge may be from the insights and competences of individual people (the source of new knowledge), found in experience or could be from a process of search- such as research into technologies, markets, competitor actions etc. This knowledge could be codified in such a way that others can access it, discuss it, transfer it etc. or it can be in tacit form, 'known about' but not actually put into words or formulae. A key contribution to our understanding of the kinds of knowledge involved in different kinds of innovation is that innovation rarely involves dealing with a single technology or market but rather a bundle of knowledge which is brought together into a configuration. Successful innovation management is about getting hold of and using knowledge about components but also about how these can be put together- the architecture of an innovation (Tidd et al., 2005). Tranfield et al. (2006) outline the phases of the innovation process and extrapolate the knowledge routines necessary to support each of the innovation phases- discovery, realisation and nurture. Taking the network perspective of innovation necessitates understanding where and how knowledge management routines impact the innovation process and what characteristics of social networks influence knowledge management and how. For example, the discovery phase of innovation relates to searching and scanning the environment to pick up and process signals about potential innovations. Thus potential sources of knowledge in the network are scanned for items of interest. The larger the social network, the more knowledge sources will be scanned and thus the likelihood of finding valuable items of interest for innovation is higher. The knowledge sources located are then potential members of the network to enable any collaborative efforts. Utilisation of the actors in the network then enables access to, capture and articulation of this knowledge in an explicit usable format.

The first phase of any innovation process relates to discovery and involves searching the external environment to identify potential shifts and unfulfilled needs that provide the opportunity for potential innovations. The knowledge inputs for this phase of the innovation process necessitate the organisation spreading as wide a net as possible to capture information from relevant knowledge sources. The broadness of the domain makes it impossible for any one individual (or even organisation) to adequately search all potential sources. The use of social networks to search for and access knowledge regarding emergent shifts in the external environment improves the organisations searching ability to identify appropriate opportunities for innovation. The social network literatures inform practice on how best to search for and access valuable knowledge through social networks. For example, Granovetter (1973) proposes through his weak tie theory that weak tie relationships, defined as not emotionally intense, infrequent, and restricted to one narrow type of relationship enable a focal individual to contact another who resides in a different social circle and hence access non-redundant knowledge.

Burt (1992) proposes, through his structural hole theory, that boundary spanners, defined as those

actors in a network who connect otherwise unconnected actors, gain access to novel knowledge in a timely fashion, as well as bargaining power. Once the *search* process is complete, the more effectively an organisation can *capture* and *articulate* the knowledge from these networks, the richer the opportunities they have to feed their innovation efforts. In order for meaningful knowledge transfer and learning to occur, the social networking process requires direct and intense interaction, collaboration and cooperation between individuals with relevant knowledge and expertise, within the structure of the network (Hansen, 1999) so that knowledge can be internalised in the organisation and given expression in a form understood by those tasked with exploring its innovative potential. The requirement for intense interaction emphasises the importance of the strength of the relationships and the requirement for individuals with relevant competencies emphasises the need to investigate the absorptive capacity of the network.

The second phase of the innovation process relates to *realisation.* This relates to how the organization can successfully implement the innovation and selecting from the range of available innovations those which the organization will work on. It involves firstly screening and selecting appropriate actions to be progressed along the innovation process. Selection decisions are based on available knowledge and expertise so the adoption of a cooperative team-based, consensus approach to decisions is facilitated by having access to a greater network of expertise, knowledge and diverse perspectives to enlighten the selection process. It requires that the knowledge and innovations are articulated such that they can relate to each organizations context and particular challenges. Possessing a wide diverse network of actors and thus drawing on multiple perspectives, knowledge and expertise can facilitate this contextualization and ensure effective selection decisions are made. An organisation must strive to identify and access all pertinent information and absorb this knowledge to enhance their decisions. Better informed decisions regarding the approval of concepts will enhance the likely success of the innovative actions pursued. Understanding how the actors interact and the network structures can enable development of strategies to further enhance collaboration for this phase of the innovation process.

The third phase of the innovation process relates to nurturing the innovative actions approved from the realisation phase. The challenge of this phase is to transform the concept into a reality and align it with the needs of the market. The further along this phase an action is then the more difficult it is to change the design. Consequently organisations need to access information to ensure the design and subsequent development is correct. The use of concurrent engineering and co-design teams are common in this phase of the process to enhance the knowledge flows and eventual output. Concurrent engineering brings together all relevant stakeholders (e.g. design, manufacturing, logistics, sales, etc.) to collaborate on the development of the action; co-design engages suppliers and other independent organisations to work together on the design of the future innovation. The opening-up of this phase of the innovation process to input from knowledge sources external to the organisation enhances the expertise and knowledge available, increases the creative capability to solve problems encountered and ensure that relevant stakeholder requirements are incorporated into the design and development activity. Since potential errors are minimised by collective knowledge sharing, such collaborative routines have the potential not only to develop superior innovations but also to reduce the cost and time of development. Such leveraging and integration of necessary resources from the social networks facilitate successful exploitation of the 'new' knowledge opportunity.

The exploitation of value from the developed actions is the primary objective of this phase of the process. The ability to commercialise developed actions is essential to the long term sustainability of any organisation. Knowledge inputs for this phase of the process relate to how an organisation can ensure the market adopts the innovation and what mechanisms can be used to protect intellectual property from competitors. Organisations must be careful when securing intellectual property that the associated secrecy does not adversely affect the necessary knowledge flows to the innovation process or encourage behaviour by individuals within the network that undermines knowledge exchange for mutual benefit. Thus management of collaborative efforts within these constraints requires an understanding of collaboration mechanisms such as trust.

3 METHODOLOGY

The case studies detailed below are of a number of university-industry collaborations studied through longitudinal research by the researchers. The

methodology adopted consists of a series of semi-structured interviews over the life of the network to assess the networks evolution, understand the structures, routines and practices of the network and identify the factors influencing positive network behaviour. The interviews are conducted with key members of the collaborations management team who can provide both strategic and operational level insights into the network functions. Interviews were conducted every eighteen months. These case studies were chosen for analysis as they were created by multiple organizations to advance their scientific understanding and generate knowledge that they could exploit for potential innovations. The study of these networks began in 2004. The interview transcripts were analysed using a number of social network analysis determinants as themes. This analysis provides insight into the mechanisms of a social network and how these mechanisms and network characteristics explain how social cooperation and collaboration is initiated, enhanced for knowledge sharing and innovation. A full description of the three cases used is provided in Dooley et al (2010).

4 SUMMARY FINDINGS

All three network cases were established for the purpose of generating and advancing the knowledge base of their scientific discipline for development of future medical treatments. The knowledge diversity of the life sciences context makes it impractical for a single organization to internally consolidate the span of expertise required (Powell et al, 1996). By participating in knowledge networks, organisations gain privileged access to knowledge-producers involved in discovery, translational and clinical research activities that facilitate their innovation process. In all three cases, the motivating factor for partners to collaborate was to access 'valuable' knowledge areas which they lacked internally.

All three networks are focused on emerging areas of their scientific field where a disruptive shift has resulted in industry lacking the required capability or scanning capacity.

4.1 Searching for Knowledge

In all three cases, the impetus for venturing into the external environment to locate suitably interested organisations came from the lead academic within the university organisation. These key individuals foresaw the significant opportunity for their own organisation and potential partner organisations, should collaboration occur and thus actively promoted the virtues of collaboration to interested parties. All three lead academics fit the mould of "knowledge brokers" (Hargadon, 2002) or "boundary spanners" (Donaldson and O'Toole, 2007) by providing the 'weak' ties (Granovetter, 1973) that nurture embryonic relations into a collaborating network. Each of the lead-academics had established a reservoir of influential contacts as a legacy of their past endeavours and could exploit these contacts to establish linkages with potential organisational partners.

The attraction for partnering organisations was that network participation enhanced the scientific scanning abilities of each organisation, allowed access to proprietary knowledge and compound libraries and provided a cost-effective mechanism for undertaking the research work. While initial discussions regarding network formation took place between lead academics and like-minded scientific peers within industrial organisation, once interest was established, the size of the network increased as individuals from the organisations became involved to formalise contractual terms of reference for the interaction and protect their institutions position. This increased the bank of sources of knowledge available for the knowledge sharing and innovation process.

A large diverse social network is most effective where members of the network are not only connected to each other but have an awareness of each others expertise such that knowledge of value can be accessed and/or combined appropriately. In the cases investigated here this process of awareness initially begun on a formal basis as all three networks were established as closed networks, where partner selection was based on alignment of competencies, expertise and interest in the knowledge generating activities of the network. During the formative stage of the network, the academic members had to 'sell' the network by communicating the latent expertise and its value to prospective partners.

In all three cases, there is an obvious bias towards interaction by industry personnel with university researchers (perhaps due to this being the locus of the networks active research capability but maybe also because of competitive fears). This suggests the academic institutions are in central positions in the network. However there is evidence within certain networks of increased awareness of competitor industry's competencies and fledgling

collaborations between synergistic industrial partners. This is suggestive of strong ties between university-industry partners and weaker but developing ties between industry-industry partners. Universities are therefore acting more as knowledge brokers and enablers of network development rather than the ultimate and only benefactors of the network. Industry needs to obtain advantages from the network or they will quit the network. Thus indications of developing ties between industry and industry within this network should serve to strengthen the search capacity of the network and ultimately the knowledge sharing and innovative capability of the network.

4.2 Capturing & Articulating Knowledge

Possessing connections to and awareness of these knowledge sources is only valuable to the extent to which this knowledge can be accessed, captured and articulated in a way that makes the knowledge useful to a party. Access to the knowledge sources in the cases explored was facilitated through a number of structured and informally emerging channels. Structured channels included those formally agreed as part of the network's institutional agreement or internal routines. These included scheduled on-site visits at university laboratories, access to centralised laboratory information systems and intranets and formalised project and annual reports. These are important channels in that they exchange explicit (the 'what') knowledge that has been generated by the networks scientific endeavour.

However, the ability of these channels to exchange more tacit knowledge (the 'how' regarding the newly created knowledge) is poor. More informal channels of knowledge exchange evident in all three networks included co-location of industry staff in university for short periods, one-to-one discussions between researchers following on-site visits, during social gatherings following such events, during conferences or during follow-up communications via email and telephone.

The capture and articulation of discovered scientific knowledge involves an engrained process of conceptual thinking common to research scientists. At a generic level, the scientists have an encultured knowledge of language and expert-knowledge associated with the discipline. As research scientists from the partner organisations interact at scheduled meetings of the network and informal communications, trust and friendships develop. This increased affinity also narrows the cognitive distance between individuals, increases absorptive capacity and provides a ready basis for knowledge transfer.

4.3 Transferring Knowledge-Contextualise/Apply

The realisation phase of innovation requires that the knowledge is contextualised and applied to particular organisational contexts. Given the highly encultured language and expert knowledge associated with the scientific disciplines, this is potentially a significant barrier to interaction and knowledge absorption. However, given that all individuals engaged in the networks possess scientific qualifications (majority being Ph.D.'s) and all are motivated by similar discovery focus, then the networks have actually become communities of like-minded peers. Irrespective of their particular organisational origins, the network members firstly view themselves as research scientists, whose purpose is to better understand their scientific domain. Yet despite this common foundation, each network member has their own particular area of science and expertise that challenges others assumptions and mental models and creates the creative tension necessary for learning and scientific discovery. While the initial network founders often have a previous legacy of interaction that has validated their scientific credentials and thus facilitates trust and cognitive proximity, newer members require time and interaction to achieve similar contentment. One PI researcher within case 3 went so far as to identify the tipping point for network interaction as that when everyone trusted the science that the other was doing. This common frame of reference and absorptive capacity is the minimum requirement for contextualising and applying knowledge to particular organisational contexts.

A number of mechanisms are utilised to contextualise and apply the knowledge to members' contexts. The knowledge available within the organisational nodes is applied to solve specific scientific problems which have been agreed as mutually beneficial to the network participants. This occurs through specified research projects, where relevant network members contribute knowledge, compounds, staff and capacity to achieve objectives and generate new knowledge through scientific discovery. The new knowledge generated through exploration provides inputs and leads for exploitation within the innovation processes of the network's organisations. Dependent upon

contractual conditions agreed during the network's formative phase, the newly discovered knowledge will be exploited unilaterally or collectively and result in patents, leads for new treatments, licensing agreements, new operational processes or even the creation of new joint ventures.

Once research discoveries are achieved within the network laboratories, they are communicated with network members as per channels defined in the contractual agreements. While these channels remain as the networks mature, additional communication channels evolve organically. All three cases have established centralised information systems for sharing information and have regular on-site meetings of the network members to discuss operations and nurture the exchange of both explicit and tacit knowledge between members. These communication channels have been supplemented by telephone and email communication between peers which is driven by specific scientific challenges, as well as informal meetings at conferences and site visits.

Evidence of the transfer and contextualisation can be found in the outputs achieved to date from the networks collaboration. Respondents highlight that the early years of network operations were occupied establishing the culture, routines and project portfolios for the network. This period demanded partner commitment for little immediate value other than an enhanced scientific scanning capability. However, the later years resulted in 'real value' being transferred to the partner organisations from the network generated knowledge.

4.4 Absorbing Knowledge-Evaluate/Support/ Re-Innovate

All three cases under study have evolved and expanded in terms of size and scope over the period of study providing indications of the success of the networks to date. While much of the detail regarding direct support provided by network members was specified in the consortium agreements, certain partners surpassed their indicated support by allocating additional equipment, compounds and personnel to the network. While member support of the network was primarily in terms of financial funds, contribution of staff in terms of full-time equivalents and background IP in terms of patents and scientific compounds, some of the most valuable contributions occurred organically as research scientists interacted together within the context of specific and synergistic scientific problems. The partners to each network not only transferred knowledge back to their home organisation but also championed the collaboration by developing linkages with appropriate new researchers within their organisation to enhance the networks value.

As the external environment is constantly evolving, the networks themselves have recognised the need to adapt to remain relevant and valuable to the collaborating partners. A key challenge facing the case consortia is that after prolonged interaction and learning, the industrial partners no longer view the university's research expertise as internally lacking within their own researchers. This reduces the central position of the university and consequently the knowledge and power gains the university can obtain from the network, thus isolating it to the periphery of the network. In light of this, the lead-academic has incorporated an emerging scientific area as a minor part of the third cycle and this is likely to become a more significant part of the next cycle in order to maintain scientific and commercial relevance to partner organisations. Similarly in case 2, the network evolution has resulted in partner organisations within the network establishing smaller, parallel consortia to pursue new opportunities identified during interaction. Rather than this being viewed as a threat to the original network, it is seen as evidence of deepening relations between organisational partners and added value of participation.

5 CONCLUSIONS

With increasing environmental uncertainty, organisations are collaborating more with external parties, including other organisations and educational institutions in order to access knowledge to facilitate innovation. It is acknowledged that the key to survival is to recognise that the locus of innovation is found in networks of learning, knowledge sharing and innovation. Thus, in order to effectively manage the innovation process, one must understand the structure and function of the network contributing to the generation of innovations. Previous research identifies the benefits of social networks for the creation of new knowledge (Zander and Kogut, 1995; Trott 2008) and the implications of specific social network characteristics such as density, cohesion, strength of relationships and existence of relationships, on knowledge management for innovation efforts. Thus, understanding the implications and influence of

collaboration within networks is key to facilitating effective management of knowledge sharing and innovation processes.

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