Managing occupational boundaries to improve innovation outcomes in industry-research organisations

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ABSTRACT

Commercialisation activities combining the discoveries of one occupational group, such as scientists, with the commercial skills of managers involve interactions across occupational and organisational cultures. This article explores the challenges posed by working across occupational and organisational boundaries, and describes management techniques developed informally in four Australian organisations to address barriers to knowledge transfer. It identifies the existence of Knowledge-stewarding Communities of Practice (CoP) that span organisational boundaries and impact commercialisation outcomes. It also presents recommendations for management practice based upon diversity management and innovation theories. The context of the study is Australian hybrid industry-research organisations composed of academic, government and industry personnel. Semi-structured interviews with a total of twenty scientists, engineers and managers focused on their experiences of knowledge sharing across organisational and occupational cultures, and methods used to manage these boundaries. The existence and efficacy of boundary-crossing

individuals and boundary object strategies are explored. A generic process management model of innovation is extended to acknowledge and accommodate occupational and organisational cultural proclivities towards exploration or exploitation, and to stimulate future research.

Key words: Cross-boundary knowledge sharing, Innovation, University-Industry Partnerships, Communities of Practice (CoP), Hybrid Organisations, Commercialisation

Commercialisation: Difficult, Demanding and Dangerous?

When asked to nominate a metaphor to describe the experience of working to commercialise a promising innovation as part of a hybrid organisation composed of industry, research and government organisations, two managers volunteered the same striking phrase: herding cats. Several spoke of chaos and the challenge of managing organisational webs of 'many to many relationships' that spanned occupations, organisations, public and private sectors. Others described the use of political tactics in attempts to satisfy diverse constituents with incompatible motivations and goals. One researcher described working in a publicly funded institution as travelling in an armoured tank, compared to which commercialisation work in a hybrid industry-research organisation was riding a moped, through busy traffic, without a helmet. Collectively the informants viewed working across organisational and occupational boundaries as difficult, demanding and from a career perspective, potentially dangerous.

This article explores the challenges posed by working across occupational and organisational boundaries, and describes management techniques developed informally in four Australian organisations to address barriers to knowledge transfer. It also presents recommendations for management practice from diversity management and innovation theories. The context of the study is hybrid industry-research organisations, also known as 'Triple Helix' organisations, in the Australian Cooperative Research Centres (CRC) program. These organisations are engaged in producing Mode 2 knowledge (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow 1994), intended to be of practical use to industry, government or society at

large. The research question, explored using a qualitative approach, concerns the management of occupational boundaries to improve organisational processes and outcomes in Australian Cooperative Research Centres.

Triple Helix Organisations, the Inter-Organisational Organisation

Since the 1980s, governments of industrialised economies have looked to innovations involving the generation of, and reconfiguration of knowledge as a means of maintaining their competitive advantage (Gibbons et al. 1994). The evolution of Triple Helix organisations in which private firms and publicly funded research groups collaborate has been traced across Europe, the USA, Latin America and Asia (Etkowitz & Leydesdorff 2000). In these hybrid industry-research organisations, knowledge management, including the identification, capture and evaluation of innovations, occurs across organisational and occupational boundaries. Significant financial and intellectual investments exist in Triple Helix organisations, yet little attention has been paid to the existence of Communities of Practice (CoP) or boundary management techniques within these entities, despite their potential to influence knowledge sharing and commercialisation outcomes.

The Australian CRC program provides an example of government intervention intended to stimulate innovation, and produce economic returns through fostering collaborative arrangements. CRCs are composed of academic, government and industry members working together to bring an invention to market. CRCs operate as trans-disciplinary organisations, of a fixed funding duration, intended to link knowledge discovery and use (Department of Education Science and Training & Howard Partners 2003).

The study of hybrid industry-research organisations is important due to their anticipated contribution to national economies, their rapid spread and increase and the concomitant investment of public and private funds. For example, by 1999 hybrid research-industry organisations had already become the organisational form receiving 69% of industrial funding for academic research and development in the USA (Tornatzky, Lovelace, Gray, Walters & Geisler 1999). In Australia alone, a total of

A$925.9 million is being provided for CRC funding between 2006–07 and 2010–11 (Department of Education Science and Training 2005).

To date, groups of researchers joining forces with government and business entities to bid for research funding have been the driving force in creating Australian CRCs. In the early years of the CRC programme over eighty per cent of CRC professionals had a research background, with a thirteen per cent minority drawn from industrial and government sectors (Liyanage & Mitchell 1993). While recent evaluations of the programme recommended increased focus on the management and production of commercial outcomes (Department of Education Science and Training & Howard Partners 2003) it is clear that research groups pursuing knowledge production have been the driving force behind many CRCs.

The Occupational Culture of Researchers.

Numerous contributions from history, sociology and anthropology exist to substantiate the claim that researchers share a distinctive occupational culture (Traweek 1993) which, consistent with the nexus view of organisations (Meyerson & Martin 1987), may be imported into an organisation to function as a distinctive subculture. Scientists have been explicitly identified as insulated from their social milieu, bound together by a common language, displaying occupation specific rituals and comprising the exclusive audience for, and judges of, each other's work (Geraci 2002; Kuhn TS 1970, 1977; Tullock 1993). Several studies (Cole 1992; Gieryn 1999; Merton 1957, 1968; Pelz & Andrews 1976; Steiner 2000) have identified institutionalised norms that direct the behaviour of researchers, (including free sharing of findings, universalism, disinterestedness and organised scepticism), and that are internalised through socialisation and training. These norms are reinforced by systems of reward and sanctions largely based upon the esteem and approval of peers, and are viewed as essential for the pursuit of certified knowledge. In fact, the hardest problems require the biggest teams, and there has been acknowledgement that the critical issues in research are as much social as technical (Button & Sharrock 1998). In short, research involves more than hypotheses and equipment. It also involves communication and occurs in a socio-cultural context involving members of specialised CoP (Kuhn T 2002), or 'disciplinary matrixes' (Kuhn TS 1977).

Working Across Organisational and Occupational Boundaries

Increasingly, the social sciences use boundary concepts to examine interactions between individuals, groups and nations (Lamont & Molnar 2002). In the context of innovation studies, boundary concepts have been used to describe and explain interactions between groups of scholars and practitioners, (Kuhn T 2002; Lehrer & Asakawa 2004; Nowotny, Scott & Gibbons 2001; Turpin & Deville 1995; Van Maanen & Barley 1984; Ziegler 1997). Boundaries between different research disciplines have also been examined (Epton, Payne & Pearson 1983; Gibbons et al. 1994; Turpin, Garrett-Jones & Rankin 1996), as have the borders between 'hard' and social sciences, (Gieryn 1999). Theoretical applications of boundary concepts to occupations include Douglas, (1982), Martin, (Martin E 1998), Lamont and Molnar (2002), Turpin (1999) and Martin (Martin J 2002).

Previous research suggests members of research and commercial occupations, working together in hybrid industry-research centres will almost inevitably experience tension between their occupation specific norms and beliefs (Gibbons et al. 1994; Hackett 2005; Kuhn T 2002; Sitkin & Stickel 1996; Steiner 2000; Trice 1993). Tension between researchers' exploratory work behaviours and business managers' emphases on rapid exploitation of commercial opportunities (Cyert & Goodman 1997; Hayes & Fitzgerald 2007; March 1991) can be exacerbated in Triple Helix organisations with unclear authority structures, particularly if individuals participate on a voluntary basis, as is the case with Australian CRCs.

One imperative for hybrid organisations appears to be ensuring that constructive and not destructive conflict results from the expression of occupational and organisational difference. Research points to the value of 'multicultural adaptation rather than assimilation' in collaborations across research and industry occupational and organisational boundaries (Turpin 1999: 244) and the desirability of cultural difference between industry and research groups (Yee 1996). If commercial and research cultures and organisations merge, and become less distinct, it is possible that the complementary skills, abilities and knowledge that provide the rationale for industry-research collaboration will be lost.

Steiner (2000) asserts that more than conventional science skills are required to be an innovator, or to produce science of interest to industry. In fact, she proposes that the norms and beliefs inculcated in a good scientific education may inhibit the ability to work with industry. This is due to the conflict that exists between scientific mental models, that view knowledge making as the desired goal, and commercial mental models devoted to moneymaking. Thus, a boundary-crossing researcher-manager, able to shift their cultural frames and decide when to be a 'good' researcher and work by the book, and when to be 'incompetent' and digress from accepted scientific practice can be invaluable to innovation efforts (Steiner 2000).

Similarly, diversity and multicultural literatures recommend secondment as a way of providing the tacit knowledge needed to work across cultures through immersing selected individuals in an unfamiliar culture (Ely & Thomas 2001; Fernandez, Mutabazi & Pierre 2006; Pires, Stanton & Ostenfeld 2006). The intent of secondment is to develop some of the characteristics of boundary-crossers, individuals equally at home in more than one organisational or national culture. In addition to the desirability of boundary-crossing individuals, Kuhn (2002) adds the use of boundary objects in the forms of artefacts, activity routines or reified concepts, as a potential means of managing boundary conflict in a constructive manner. Furthermore, a boundary is not inevitably a barrier. Boundaries can be interfaces which facilitate the production of knowledge, and 'boundary objects' whether material objects, organisational forms, spaces or procedures, can enable communication between communities (Star & Griesemer 1989).

Innovation and Occupational Boundaries

> *… external pressures for change do not have any mechanical effect on research practices and ideals, as they are always filtered through the historically, socially and cognitively constructed stock of values, norms and codes of behaviour… This means that the cultural elements act as a 'buffer' that to a certain extent can save university research from being a mere target of the external steering by economical and political actors (Hakala & Ylijoki 2001: 378).*

National systems of innovation and the rise of 'Mode 2' knowledge production (for practical application, carried out in non-hierarchical, transient organisations that are separate from university structures (Gibbons et al. 1994; Nowotny et al. 2001)) have affected research culture. External pressures for change, such as expectations of financial returns and increasing commercialisation of innovation, can influence the boundaries and strength of occupational subculture (Trice 1993). Since the early 1990s, successive Australian governments have sought to encourage collaborative research projects between industry and publicly funded research institutions, such as the CSIRO (Commonwealth Scientific and Industrial Research Organisation). Criticisms of public policies making receipt of public research funding contingent upon participation in industry linked projects, highlight the potential for conflict between research norms and commercial proclivities for speed, confidentiality and profit (Harman 1999 2001). Academics have investigated research communities' responses to pressure to produce commercially oriented work in Australia (Harman 1999 2001; Turpin 1999), Finland (Hakala & Ylijoki 2001) and the USA (Louis, Blumenthal, Gluck & Stoto 1989). These *intra-occupational* studies serve to illustrate the dynamic nature of subcultures. Significantly, they also point to the need for *inter-occupational* studies of government-sponsored commercialisation efforts. Hence, inter-occupational comparisons are necessary to obtain balanced insights into the process of innovation, which of necessity spans research-producing and research-using occupational cultures and organisations.

Communities of Practice and Triple Helix Organisations

Recently, one of the authors (Hayes 2007), has discovered research members of CRCs acting as inter-organisational, Knowledge-stewarding CoP. While previous work has considered Triple Helix organisations from a range of theoretical frameworks (Etzkowitz & Leydesdorff 2000; Gibbons et al. 1994; Nowotny et al. 2001), this is the first identification of Knowledge-stewarding CoP being imported into, and growing within, hybrid industry-research organisations. CoP are characterised as voluntary groups who work and learn together, distinguished by their passion for a particular knowledge domain, sharing similar roles and skills and possessing a common bond (Wenger, McDermott & Snyder 2002). Wenger et al. (2002) expand upon the four different strategies to encourage development of CoP first identified by the American

Productivity and Quality Centre. These are Helping, Best-Practice, Innovation and Knowledge-stewarding CoP. Helping CoP provide physical or virtual environments for members to discuss and solve common and newly encountered problems. Best-Practice CoP develop and disseminate guidelines and procedures to define, and extend the use of, best-practices for their particular domain. Innovation CoP are deliberately cross-functional in composition, and 'intentionally cross boundaries to mix members who have different perspectives' (Wenger et al. 2002: 77). Finally, Knowledge-stewarding communities are primarily devoted to organising, upgrading and distributing knowledge frequently used by members.

While the deliberate combining of the knowledge and skill sets of research and business personnel may suggest that whole Triple Helix organisations might be categorised as Innovation CoP, the presence of dedicated business managers, and overt expectations of commercially valuable results argue against this possibility in Australian CRCs. Instead, the inter-organisational research teams identified in the CRCs show characteristics of Knowledge-stewarding CoP, and this has important implications for management practice within CRCs.

CoP do not necessarily work to produce defined outcomes or operate with a definite agenda or timetable (Wenger & Snyder 2006). CoP last as long as members want them to and, because they are populated by volunteers, do not respond well to management supervision (Wenger & Snyder 2006). While managers may regard research groups working within CRCs as specialised technical teams, the researchers describe attitudes, beliefs and assumptions that suggest they comprise a separate CoP within each CRC (Hayes 2007; Hayes & Fitzgerald 2007). This article questions the homogeneity of CRCs. It proposes that research specific CoP are embedded within CRCs, posits that Knowledge-stewarding CoP can exist as part of Triple Helix organisations, and that these CoP span organisational boundaries as shown in Figure 1. The CRC programme may well have provided Knowledge-stewarding CoP with opportunities to obtain organisational legitimacy and on-going funding that they previously lacked.

(insert Figure 1 here)

Thus, although there is ample evidence of the existence of boundaries between occupations and institutions in hybrid organisations, little is known about how boundary management occurs. This poses the following question: How can occupational boundaries be managed to improve organisational processes and outcomes in Australian Cooperative Research Centres?

METHODOLOGY

In evaluating a research paradigm to study occupations involved in commercialisation, the effects of communication and socio-cultural influences on the development of new technologies are important considerations (Kranzberg 1997). Similarly, commercialisation involves teams (Steiner 2000) and is characterised by iterative communication (Rogers 1996). These features necessarily influence methodological choices towards those that provide a flexible and holistic approach to social systems.

A qualitative, semi-structured approach was employed in this research. A CRC typically consists of individuals from a variety of occupations aligned with a particular industry, located within a broad context of Australian society and public research policy decisions. The ability to effectively identify, isolate and accurately measure both dependent and independent variables within a natural setting is limited. In addition, the scant literature on managing across the boundaries of industry-research partnerships does not support attempts to define dependent and independent variables. As social activities occurring within organisational and national cultures, commercialisation processes in a complex social system suit holistic investigation using qualitative methods.

To permit holistic, in-depth exploration of the research questions *case research* was selected as the methodological framework, or comprehensive research strategy by which data was gathered. In this study, case research is used as a systematic way of collecting and analysing data from bounded entities, capturing events in a framework within a particular environment. The methodology is broadly based upon that of the case study, but differs from prescriptions for case studies by the absence of a priori theory and the use of thematic analysis (Eisenhardt 1989).

A total of twenty scientists, engineers and business managers were recruited from four CRCs. Two of these CRCs were from the Information and Communications Technology sector and two were from the Biomedical sector. Two CRCs had graduated from the program, and two were currently receiving CRC program funds. The organisations' maturity ranged from newly formed with only a few years of operation, to twenty years of operation for a publicly listed company that developed out of the CRC program. The four CRCs (IT Graduate, IT Current, Biomedical Graduate and Biomedical Current) were composed of individuals representing over 60 private companies, 11 academic institutions and 13 government bodies.

Each of the four CRCs, selected on the basis of age and industry, constituted a bounded system for study in its own right and was part of a set of collective cases. Stake (2000) has commented that, while permitting less inherent interest in each organisation, collective case studies do provide the opportunity to investigate, and gain insight into an issue of interest. Also, the choice of four organisations reduced the possibility of patterns stemming from factors unique to one organisation mistakenly being viewed as representative of interactions between research and commercial occupations. For example, the idiosyncratic actions of a particular individual would not be likely to appear in all four CRCs. In matching the CRCs by industry, and by current or graduate funding status, the opportunity to observe similar results across one or both dimensions (literal replication) or opposite results (theoretical replication) is incorporated into the design (Audet & D'Amboise 2001). In addition, groupings of occupational members may turn out to be sufficiently distinctive to be considered embedded cases within the CRC organisations (Yin 1994).

The participants' experiences and perceptions of working across occupational and organisational boundaries were recorded and transcribed verbatim. QSR N-Vivo® software was used to aid detailed coding and analysis of the collected research material, facilitating the interpretation process. Member checks, achieved by providing the data and interpretations to participants for correction, verification and challenge, were used to increase the credibility of the research. Through the analytic phase of the project, the research material was found to cluster around a number of

core themes. Through a reflective, iterative process, we interrogated theme content to explore relationships between and within the themes.

Despite the suitability of the selected methodology, the research findings depend upon the memory, insightfulness, and honesty of the interviewees. The findings are also constrained by time, place, and the changeable nature of individual perspectives. Consequently, the findings cannot be readily extrapolated to other contexts. However, as the following sections illustrate, the insights provided by the interviewees extends existing theory to consider the potential impact of organisational and occupational barriers on the functioning of Triple Helix organisations. Further, the researchers themselves bring with them a range of experiences that may influence the data findings. However, careful consideration of findings, discussions, checking and rechecking material and meaning helped to reduce the potential for researcher bias.

RESULTS

During semi-structured interviews lasting between 30 and 90 minutes, participants were asked questions about their experiences working with research and commercial groups in their particular CRC, and about strategies currently used to manage occupational and organisational boundaries. There was unanimous agreement that two distinctive groups exist in the organisations studied, broadly based upon membership of research or commercial occupations. The key boundary markers emerging from analysis and comparisons of the interviews are invisible, existing in the beliefs, values and assumptions held by the two communities.

Evidence of Knowledge-stewarding CoPs within Australian CRCs

As described in the introduction, Knowledge-stewarding CoP are characterised by passion for their particular area of knowledge, voluntary association and an emphasis upon knowledge production. Research interviewees' comments strongly support identification of their groups as Knowledge-stewarding CoP. For example, a researcher volunteered the need to support members beyond those required for the immediate task:

> *…[we] maintain involvement of many, many researchers who you might wonder why they're there because they're not playing part of a coherent project at any particular time, [but] they're part of a family… (Researcher, IT Graduate)*

Similarly, other researchers described committed, tight-knit, social groups that worked together for ten years before joining industry and government partners to create a CRC:

> *We had parties and we boozed hard, but that was a real team and we all knew where we were going and we were excited by it and we were successful … (Manager, IT Graduate)*

Even when members of a research team move to different organisations, or even different continents, links are maintained:

> *I see all my colleagues in the PhD community definitely. I still see most of them or know where they are and keep in contact. They've spread far and wide across the earth. (Manager, IT Current)*

The existence of an enthusiastic team of supporters was also emphasised, as a pre-requisite to successful innovation:

> *… make quite sure that you have a community, it doesn't have to be all that large, but a community that believes in it. Pragmatically the thing that you have got to start with is a community of people who believe in it. (Researcher, Biomedical Graduate)*

Researchers have the autonomy to choose whether and when to join a CRC and when to leave. The inability to control staff participation frustrates managers used to having clear authority over employment. A researcher commenting on the challenges of a CRC management role advised:

> *… you could have a [government research institution] person go back to Mum. And all that did was create people issues, so it was a very, very difficult role trying to run one insofar as you ended up with the responsibility for having a positive outcome when everyone else was in there for their own interests. (Researcher, Biomedical Graduate)*

While researchers clearly enjoyed participating in their specialised, Knowledge-stewarding CoP, managers at times perceived the cohesion and solidarity of the research groups as exclusionary, and a barrier to successful commercialisation.

> *There was a long period when it was entirely scientific. Then they tried to create a little operations section and it made no progress whatsoever because the scientific establishment just froze them out the whole time. All they did was stonewall every time anyone tried to get a commercial product. (Commercial Engineer, Biomedical Graduate)*

Interviewees recognized the homogeneity of the interests of the members of the Knowledge-stewarding CoPs, and the challenges it presented to commercial managers:

> *You are dealing with a much smaller group of people, they are from, basically, an almost identical backgrounds. …. More often than not, they do have some sort of conflict of interest [with government and business participants], and the way they are dealing with the project and their expectations are very different as well. So, it is very difficult. (Researcher, IT Current)*

All informants freely identified a research based, Knowledge-stewarding CoP embedded within the four CRCs. Researchers with strong enthusiasm for a common knowledge domain voluntarily built connections between a range of organisational locations for research activities (see Figure 1) over a period of time prior to the existence of the CRC. This shared history strengthened the associations between the researchers who made up the Knowledge-stewarding CoP working within each CRC.

Secondment

Informants explained that although the first CRCs were unequivocally encouraged to temporarily transfer individuals between the participating organisations, this did not commonly occur. The Biomedical Graduate CRC had used physical secondment to immerse an individual into the other occupational culture, possibly with a view to developing boundary-crossing individuals:

> *…by putting a scientist within a company, … that created a day-to-day experience of the drivers of the company and commercial concerns so that the work was done in the context of the need for specifications, for reproducibility, for product integrity. (Researcher, Biomedical Graduate)*

This approach was under active consideration in the IT Current CRC. However, a researcher from the Biomedical Current organisation raised practical objections to the use of immersion via secondment:

> *Once you start off with parties that are not already in the same location that was never going to happen because what you would require is for the parties to effectively give up their best people to somewhere else. And it just wasn't going to happen and it hasn't happened in our place. (Researcher, Biomedical Current)*

The low incidence of secondment in the four CRCs suggests that it has proved unpopular, possibly due to thick organisational boundaries, especially between business and research organisations. Of the twenty individuals interviewed, only four had experienced physical secondment. Of these four, three came from the Biomedical

Graduate CRC. No informants from the two currently funded CRCs had experienced secondment. Given that secondment appears to becoming increasingly unpopular with CRC organisations, it is unlikely to provide a solution to inter-occupational and inter-organisational tensions in the future.

Boundary Crosser and Boundary Object Strategies

Use of the boundary crosser and boundary object strategies advocated by Kuhn (2002) to lessen the impact of occupational and organisational boundaries were described by respondents from all four CRCs. Four interviewees displayed characteristics of boundary-crossers: key individuals who are skilled and often certified (holding educational and professional qualifications) in two distinct bodies of knowledge, and who translate the behaviour, knowledge-systems and social values of one group for the other. For example, a researcher from the Biomedical Current CRC, when asked why he had not returned to academia as planned explained:

> *When I moved into the organisation there were two subcultures which between them defined the whole culture [with] almost no point of overlap. The two groups lived on different floors and talked about each other. They had to communicate a lot, but there was very little understanding of, and very little sympathy towards one another's points of view. There was often tension, sometimes useful, but sometimes not between the two subcultures. I think the reason that I slotted into this organisation so well is that I was the only person in the organisation that had training in both subcultures. And so I loved it from the start, it was a foot in both camps and it just made life much more interesting. (Researcher, Biomedical Current)*

In addition to boundary crossers, the Biomedical Current CRC used a formal innovation management process as a boundary object to link disparate occupational and organisational groups. This process, a variant of the Stage-Gate® new product process, tracks the development of initial research ideas, manages what is included and what is left out of prototypes and moves control of the product from research to design engineering then to production engineering, and finally to business unit management. Within the Biomedical Current CRC this process, in addition to performing technical functions such as testing and validation, clearly performed bridging functions between organisational and occupational cultures. For example, it functioned as a transition mechanism through a 'grey area' when research exploration activities declined and commercial exploitation activities became dominant.

It is interesting to note that as a boundary object, the process supports structured contact between the two groups. Communication and time spent in formal meetings, negotiating and documenting agreements at the beginning of the commercialisation cycle may act as a structural intervention to decrease the likelihood of inter-occupational and inter-organisational miscommunication due to undocumented, but deeply held, norms and assumptions. The impact of exposing groups to each other and getting small, documented agreements early in the cycle is consistent with the development of shared norms and improvements in resolving intra-group differences (Bettenhausen & Murnighan 1985). Additionally, the process was reported to function as a ritual encompassing several rites, allowing controlled contact between organisational and occupational cultures, and assisting transfer of jurisdiction from inventors to manufacturing and sales management in a planned and consensual manner. The Discussion section of this article considers the possibility of developing boundary objects as substitutes for boundary crossers to aid commercialisation in Triple Helix organisations.

Management Techniques

In addition to boundary crosser and boundary object techniques, the informants described a range of other management practices used to manage inter-occupational interactions. Management techniques that accommodated the motivations and norms of both research and commercial occupational cultures were described. These include: feedback loops to provide credit, appreciation and recognition to the research team at the conclusion of commercialisation projects, promotion of the CRC name and identity as a way of defusing inter-university rivalries about which institution is seen as pre-eminent, offering recognition and prestige as inducements to researchers to work in commercial collaborations and using different versions of the same business plan for different audiences.

A commercial manager from the Biomedical Graduate CRC advocated the use a mix of monetary incentives, coercion, persuasion and contact:

> *A scientist says 'You're in that [commercial] group and therefore I don't have to think much harder about it' and you can bludgeon them down with money, you can persuade them and I think in different cases you need to use both of those approaches. In terms of building structures to dissolve that barrier I think the only*

> *thing you can do is try to make as many interactions as possible … I don't think there's any obvious solution to it. (Manager, Biomedical Graduate CRC)*

In addition to attempting to accommodate the differences between commercial and research occupational subcultures, at least two tactics pre-empted inter-occupational tension by arranging for research and commercial groups to work independently. Separate industry and research committees worked autonomously and gave direct advice to the CRC board in the IT Current CRC, and a researcher from the IT Graduate CRC explained that colleagues had avoided inter-occupational conflict by developing fledgling organisations completely within the boundaries of research groups, and then making a clean break when selling them off to commercial groups. The researcher volunteered that the companies may grow at a slower rate using this approach, but saw compensatory benefits:

> *They have sold the companies and started new companies and now they are self-funded they don't need venture capitalists. And maybe the size of the company is smaller and the growth is slower, but they can manage that and derive more pleasure from working in those companies. (Researcher, IT Graduate)*

The three individuals interviewed from the Biomedical Current CRC each identified different processes used within their CRC to manage inter-occupational tension. Consistent with commercial desires for cohesion and conformity (Pech 2001), the CEO was identified as using political processes to pre-empt conflict occurring:

> *… the CEO will canvass and potentially polarise opinion prior to meetings in order to secure smooth passage through the political minefield of the different stakeholders' opinions. …… it generally doesn't become contentious at the board level as a result of the ferreting around behind the scenes and trying to talk the issues through to a common outcome. (Manager, Biomedical Current)*

However, dissatisfaction with this political approach was evident:

> *You almost get the view that says the corporate entity, or core parties in this case, will ultimately get what they want and then the CEO's job is to manage the scientific component underneath it to suit. (Manager, Biomedical Current)*

A researcher from the Biomedical Current CRC advocated selecting only low risk, highly certain projects for research-industry collaborations. However, in his view, the cost of this compromise was a reduction in the chance of performing breakthrough research.

The variety of management techniques, including separation, acknowledging and accommodating dissimilar occupational and organisational cultural norms and

political methods of pre-empting discord indicates recognition of the challenges of managing inter-organisational and inter-occupational collaborations and a variety of formal and informal approaches in use. Consistent with theory, the existence of boundary crossing individuals and boundary objects aided collaboration across occupational and organisational borders. However, boundary crossers need to be present in the organisation and motivated to perform a linking role to be effective. The following section advocates the use of process models of innovation as substitutes for boundary crossers and presents an extended process theory model of innovation incorporating research and commercial motivations and goals.

DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

Complexities and contradictions abound in the organisational context of hybrid research centres, making them a fertile setting for future research. The existence of boundary-crossers is identified both as an accelerant of commercialisation (Cyert & Goodman 1997; Steiner 2000) and productive relations between practitioners and academics (Kuhn T 2002). The benefits of organisations having the right combination of skills in a person motivated to use them to act as a 'translator' between communities and organisations, rather than to use their expertise to build a personal power base are self-evident. However, boundary-crosser strategies to overcome occupational and organisational cultural difference rely upon the ability to identify, recruit and retain these scarce individuals. The existence of boundary-crossers or spanners is undoubtedly an advantage for hybrid organisations, but is not sufficiently robust to be relied upon as a primary mechanism for overcoming the potential for cross-occupational cultural misunderstandings. Similarly, there is a clear need for CRC-specific management techniques that while encouraging and supporting CoP, also guide their activities towards commercial ends.

Sitkin and Stickel (1996) assert that process management techniques stabilise organisational routines and tighten the linkages between them, and yet make cross boundary, cross community linkages more difficult. This contradicts the bridging function performed by the Stage-Gate® development process used in the Biomedical Current CRC. The development process appears to coordinate the activities and manage the expectations of multiple stakeholders from a variety of disciplines and

organisations. Figure 2 below shows a schematic representation of a generic stage gate process, extended to acknowledge and accommodate occupational and organisational cultural proclivities towards exploration or exploitation.

(insert Figure 2 here)

This model incorporates process theories of innovation, as shown in the linked phases of idea generation, appraisal and evaluation, production acceptance, expansion and automation, and identifies motivations for collaboration between research and commercial communities. Respondents reported that in the context of commercialisation, commercial participants were primarily interested in an innovation's potential for economic gain, whereas the researchers viewed their work mainly in the context of how it would be evaluated by their research peers. Furthermore, it indicates how the insertion of some form of ceremony to mark the movement of an innovation from exploration to exploitation phases may act as a boundary object and ease the transition of control from research to commercial communities.

An in depth analysis of the linking role performed by processes working as boundary objects in organisations could help to resolve the apparent conflict of evidence. It may be the case that while process management tools may not be applicable to basic or pure, fundamental research activities, they might aid in managing the transition between research and commercial communities. A commercial engineer in the Biomedical Current CRC commented when asked for a metaphor the CRC organisation in which he was a member that:

> *… eco-systems come to mind. People may be driven by different motivations, having different needs, part of their professional responsibilities but they manage to work together … like a pond where there's fish and frogs and they have something to share. (Commercial Engineer, Biomedical Current CRC)*

Researching methods to develop boundary objects as readily accessible and low cost methods of linking research and commercial occupational subcultures has high priority as an avenue for future research, particularly if it can help the 'fish and the frogs' to share knowledge rather than be limited to sharing only an organisational environment.

Conclusions

This research directs attention to the need to carefully manage transitions between exploration and exploitation innovation phases, particularly when they span occupational and organisational boundaries. In addition it identifies active Knowledge-stewarding CoP in four Triple Helix organisations, illuminating some of the previously reported challenges of managing Triple Helix and other forms of Mode 2 knowledge producing organisations. In addition to opportunities to research methods of developing boundary objects to assist in inter-occupational and inter-organisational innovation, this research points to future projects focussed on the management of CoP in Triple Helix organisations. Specifically, research is required to determine if CoPs of various kinds appear in other industry-research organisational contexts and in other countries. Further exploration of the motivations and tactics used by CoP and management groups in Triple Helix organisations, and of the loyalty and trust CoP members have towards other members, their employing organisation and other organisational stakeholders, are also potential sources of valuable knowledge. Investigations incorporating CoP and Triple Helix studies have potential to increase knowledge in these fields of organisational research and also improve innovation outcomes from industry-research collaborations.

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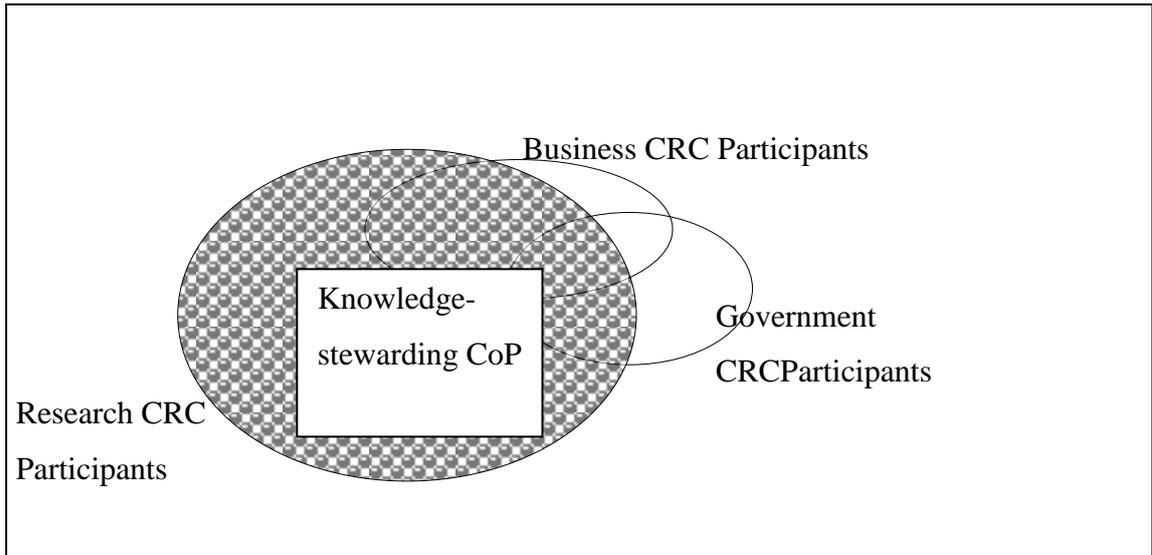
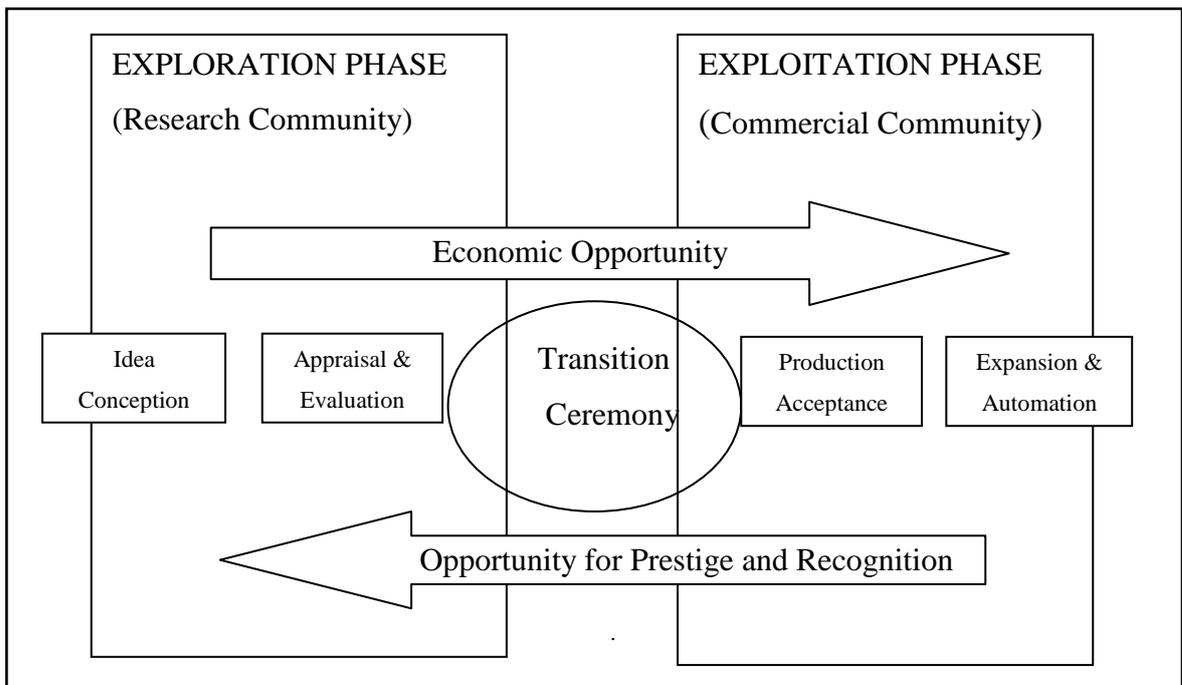Figure 1: Cooperative Research Centre showing Knowledge-stewarding CoP

Figure 2: Extended Process Theory Model of Innovation Incorporating Transition Ceremony and Recognition Feedback Loop