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# Are R&D collaborators bound to compete? Experience from Cooperative Research Centres in Australia

Samuel E. Garrett-Jones  
*University of Wollongong, sgarrett@uow.edu.au*

T. Turpin  
*University of Western Sydney*

Kieren Diment  
*University of Wollongong, kdiment@uow.edu.au*

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## **Abstract**

Increasingly, research of potential socio-economic value is being conducted within cross-sector (government, university, business) inter-organizational networks. Such networks encourage innovation and learning by breaking down rigidities in existing institutions and by providing for 'knowledge creation in the context of application'. In the process, new organizational forms for research and development (R&D) are emerging. The Cooperative Research Centre (CRC) is the dominant organizational model for cross-sector collaborative R&D in Australia. Joining a cross-sector collaborative R&D centre poses a significant challenge for public sector research managers. Success depends on cooperation with businesses and other organizations whose interests, objectives, expectations and strategies at various times converge or conflict. The game is a risky one, with the possibility of unforeseen and unwelcome consequences such as partner opportunism and competition for resources. Yet little empirical evidence exists on how researchers perceive and manage the risks and rewards of participation in cross-sector R&D centres. Our study gives voice to the researchers within these inter-organizational networks. We draw evidence from a written survey of 370 respondents from public sector organizations involved in the management and conduct of CRC-based research. The survey questions permit an assessment of the main benefits and problems in CRC participation; the management strategies adopted; and the effect of CRC participation on careers. Responses to open-ended questions in the survey convey the 'CRC experience' in the participants own words. We find the concepts of risk common in the management and organizational studies literature inadequate to explain the dynamics of interaction in cross-sector R&D. We therefore extend these through notions of the domains of 'academic', 'scientific' and 'organizational' risk. There are two broad implications of our findings: (1) participants in the CRC need to look beyond the traditionally acknowledged risks of contractual arrangements and consider risks that relate to the nature of scientific knowledge structures and the actual concerns and careers of research scientists; and (2) once these 'academic' and 'scientific' considerations are properly assessed, government research agencies and universities may need to adopt different management responses to their participation in inter-organizational R&D. We speculate that the way these potentially competing domains are dealt with has implications for (1) the survival of individual CRCs and (2) whether cross-sector collaborative R&D organizations remain ephemeral 'staging posts' or become entrenched in the national research system. We argue that cross-sector collaborative R&D organizations are an important component of a dynamic 'science system', but that they are inherently unstable organizations. They require organizational management that recognises their differences from business IORs that involve firms alone.

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# **Are R&D collaborators bound to compete? Experience from Cooperative Research Centres in Australia**

*Sam Garrett-Jones,<sup>1</sup> Tim Turpin<sup>2</sup> and Kieren Diment<sup>1</sup>*

<sup>1</sup>School of Management and Marketing, University of Wollongong, NSW 2522, Australia.  
[sgarrett@uow.edu.au](mailto:sgarrett@uow.edu.au)

<sup>2</sup>Australian Expert Group in Industry Studies, University of Western Sydney, NSW 1230, Australia

## **Abstract**

Increasingly, research of potential socio-economic value is being conducted within cross-sector (government, university, business) inter-organizational networks. Such networks encourage innovation and learning by breaking down rigidities in existing institutions and by providing for 'knowledge creation in the context of application'. In the process, new organizational forms for research and development (R&D) are emerging.

The Cooperative Research Centre (CRC) is the dominant organizational model for cross-sector collaborative R&D in Australia. Joining a cross-sector collaborative R&D centre poses a significant challenge for public sector research managers. Success depends on cooperation with businesses and other organizations whose interests, objectives, expectations and strategies at various times converge or conflict. The game is a risky one, with the possibility of unforeseen and unwelcome consequences such as partner opportunism and competition for resources. Yet little empirical evidence exists on how researchers perceive and manage the risks and rewards of participation in cross-sector R&D centres.

Our study gives voice to the researchers within these inter-organizational networks. We draw evidence from a written survey of 370 respondents from public sector organizations involved in the management and conduct of CRC-based research. The survey questions permit an assessment of the main benefits and problems in CRC participation; the management

strategies adopted; and the effect of CRC participation on careers. Responses to open-ended questions in the survey convey the ‘CRC experience’ in the participants own words.

We find the concepts of risk common in the management and organizational studies literature inadequate to explain the dynamics of interaction in cross-sector R&D. We therefore extend these through notions of the domains of ‘academic’, ‘scientific’ and ‘organizational’ risk. There are two broad implications of our findings: (1) participants in the CRC need to look beyond the traditionally acknowledged risks of contractual arrangements and consider risks that relate to the nature of scientific knowledge structures and the actual concerns and careers of research scientists; and (2) once these ‘academic’ and ‘scientific’ considerations are properly assessed, government research agencies and universities may need to adopt different management responses to their participation in inter-organizational R&D.

We speculate that the way these potentially competing domains are dealt with has implications for (1) the survival of individual CRCs and (2) whether cross-sector collaborative R&D organizations remain ephemeral ‘staging posts’ or become entrenched in the national research system. We argue that cross-sector collaborative R&D organizations are an important component of a dynamic ‘science system’, but that they are inherently unstable organizations. They require organizational management that recognises their differences from business IORs that involve firms alone.

## **Introduction**

‘I have found [nominated organization] to be selfish and self obsessed when it comes to collaborating with me and the Cooperative Research Centre. They have not been remotely cooperative – [they have] mostly been a partner for what they could get out of it for themselves.’ (ID-160)

The unprecedented growth in cross-sector (industry-academic-government) collaboration in research reflects far-reaching changes in the relationship between science, industry and society; in the ways governments fund science; in the institutions that distribute funding; and in the organizations that carry out research. Research is increasingly being carried out in organizational forms such as university-industry collaborative research centres, built around cross-sectoral and trans-disciplinary teams with well-defined socio-economic objectives in mind. Two influential models seek to explain the institutional configuration of cross-sector R&D that can be observed: the ‘triple helix’ model of university-industry-government

relations (Etzkowitz and Leydesdorff 1997) and ‘Mode 2’ knowledge production of ‘science in the context of application’ (Gibbons et al. 1994). These models are limited, however, because they fail to explain how the process of transformation is taking place in existing institutions and how the new cross-sector R&D organizations are structured and sustained over time.

The growth in cross-sector collaborative R&D centres parallels the emergence of inter-organizational relationships (IOR) in business, notably the alliances of firms aimed at introducing technologically based new products and services in markets. In this paper, we use the IOR literature to identify the salient structural features of cross-sectoral R&D centres and in particular the competitive tensions that may arise. We then explore whether these tensions are confirmed by survey of participants in Australian Cooperative Research Centres.

### **IOR and cross-sector R&D centres**

The literature on IOR is powerful lens through which to view cross-sector R&D organizations. However, it predominantly analyses inter-firm relations rather than collaboration among the public sector organizations involved in cross-sector R&D. The organization and management of cross-sector R&D is likely to be more complex than inter-firm arrangements for several reasons.

1. The organizations involved are more *heterogeneous* and have more divergent missions and ‘cultures’ than a typical IOR collaboration of several firms from similar or closely related industry sectors. Universities, for example, tend to be less hierarchical than firms, with their research groups and individual researchers enjoying considerable independence of action (Ziman 1991).
2. The coordinating influence of *market pull* is stronger in inter-firm IORs than in cross-sector R&D arrangements, which are (usually) distant from immediate markets.
3. Because of the uncertainty of R&D it is harder for partners to determine whether their collaborators are in fact ‘delivering’ on the contract. Thus the collaboration involve a higher degree of risk of failure and necessitates a higher degree of trust between the partners than in inter-firm collaboration (Nooteboom 2000). On the other hand, because of long term, speculative nature of the R&D venture, failure may be less consequential than in market-driven inter-firm collaboration.

4. Unlike, most business IORs, which are centred on the production of products or services, cross-sector R&D is concerned with the production and transmission of new knowledge which is both intangible and difficult to appropriate. The ‘spillover’ effects – e.g. of researchers learning from a ‘failed’ collaboration – may be beneficial for future cooperation among the partners and for the science system as a whole.

Cross-sector collaborative R&D centres are an important organizational expression of business networks for innovation that need to be better understood. The Australian centres that are the subject of our study claim alliances with over 1300 companies currently.

### **The CRC Program**

Our study<sup>1</sup> broadly examines the ways that public research institutions – universities and government research agencies – are transformed through formal cross-sector R&D collaboration within the Australian government’s Cooperative Research Centres (CRC) Program. There are currently 72 CRCs in operation, covering a wide range of industrially oriented research (such as polymers or advanced automotive technology) and ‘public good’ research (such as Aboriginal health or greenhouse accounting) each funded for an initial seven year term.

The CRCs are distributed organizations that rely on the voluntary cooperation of independent partners within a contractual framework. They involve collaboration between universities, federal and State (provincial) government research agencies, individual firms, and various industry-led public sector intermediaries. They may engage a chief executive and administrative and R&D staff in a central office, but most CRC researchers are employed not by the CRC itself but by the university, business or government laboratory where they continue to work. This structure means that CRCs are highly complex inter-organizational networks. For example, the former CRC for Polymers combined as participants seven companies in the plastics industry, three large federal government research agencies, four major universities and a State government department.

Cross-sector collaborative centres like the Australian CRCs and their counterparts in other countries represent a new form of research organization. They have emerged in response to

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changes in the environment of businesses, higher education and government laboratories. On the one hand, they stem from industry's growing need for research-based innovation sources outside the firm and on the other from pressures on publicly funded research to demonstrate social or economic benefit from their work. These changes to the research system are described by Etzkowitz and Leydesdorff (1997) and Gibbons et al. (1994) but the specific organizational forms that they generate are not well understood. The Australian CRCs have come into existence in response to specific government grants for cross-sector collaboration and their form is influenced by specific government requirements.

Before turning to our survey results, we briefly review (1) the ways that the organizational relations literature deals with these forms of complex collaboration; and (2) the consequences for the dynamics of cooperation and competition in centres like the CRCs.

### **CRCs as an organizational model**

We can regard cross-sector collaborative R&D centres as a class of inter-organizational relationship (IOR) which has been variously termed hybrid organization, virtual organization (or team) or cooperative network. The literature on IOR overwhelmingly deals with the case of inter-firm relations and not with cross-sector cooperation. The complementary literature on public-private partnerships (PPP) considers cross-sector cooperation, but often in the form of joint ventures or outsourcing aimed at tangible ends such as transport infrastructure rather than knowledge generation and application.

The typology and dynamics of *hybrid organizations* generally remains poorly understood (Menard 2004). Originally the term was used to describe government-created organizations in the US that combined 'not for profit' and 'for-profit' elements, i.e. having some private control and/or interest as well as some commercial or self-funding functions – in other words combining different (but to some extent still separately identifiable) sectoral forms within a single organization. It has also been applied to a wide range of inter-firm collaborations, the structure and governance of which is reviewed thoroughly by Claude Menard. Menard (2004: 345, 347) notes that hybrid organizations may be thought of as 'a heterogeneous set of arrangements' or, less politely, 'a collection of weirdos?' ... 'standing between markets and hierarchy', or 'the set of arrangements relying neither on markets nor hierarchies to coordinate'. Menard contends that 'hybrid organizations form a specific class of governance

structures' (p. 368) which share common characteristics and problems. These include the difficulties of coordinating contractual arrangements that involve autonomous partners, particularly where a high degree of uncertainty about the value of the products of the collaboration is involved; the fact that they are neither driven solely by market considerations, nor subject to the command and control of a single organization (Menard 2004). These features have important implications for their management – especially for how the balance between control and independence may be achieved. A further observation is made by Minkoff (2002: 381) describing what is special about organizations in social services that combine government service provision and community advocacy or control. She comments, 'hybrid organizations operate in multiple functional domains' by comparison with organizations that operate within 'clearly defined technical and institutional boundaries'. So hybrid organizations not only *combine* different organizational behaviours but have to *operate across* a broader and more complex span of organizational environments: in this sense they are 'boundary spanning' (Steenhuis and Gray 2006).

The term *virtual organization* (VO) has been applied as loosely synonymous with hybrid organization as defined above. For example, VOs are 'composed of different legal entities which choose to work together in a cooperative environment' (Holland and Lockett 1998). VO has also been used to refer to all sorts of arrangements, from open source software 'communities' through to distributed teams within the same firm or organization (Jarvenpaa and Leidner 1999). In Hatch's view (Hatch 1997:191) only 'when all the task activities are outsourced [do] you have a virtual organization'. What sets them apart from other hybrid organizations, according to Holland and Lockett (1998:604) is 'the extent to which virtual organizations behave [for certain activities] as if they were a single organizational entity' and their reliance on 'technology mediated communication' i.e. information systems. They are distributed (not having a single, central location) and 'are often geographically dispersed' (Holland and Lockett 1998: 602).

Turning to research and innovation specifically, Castells (2001: 67) observes the 'transformation of business management into a variable geometry of cooperation and competition depending on time, place and product' through business networks and networked enterprises. Hagedoorn et al. (2000) recognise two basic forms of formal inter-firm R&D collaboration: 'research corporations' (equity-based joint ventures where a new organization is established) and other research joint ventures which are contract-based but do not involve



the creation of a new organization. The term ‘hybrid organization’ has been introduced for collaborative research arrangements that are ‘academic organizations that span the boundaries of traditional academic research and commercial R&D’ (Lamb and Davidson 2004: 2). Gibbons et al. (1994: 6, 48) do not attempt to define the organizational forms involved. Rather they observe that ‘the types of organizations used to tackle these problems may vary greatly’ and that ‘the boundaries of organizations tend to become blurred’. So, as Lamb and Davidson (2004: 4) comment, ‘there does not seem to be much analytical discussion of the new hybrid organizational forms that operate on the boundaries of academia and industry’.

Cross-sector R&D differs from IOR that involve firms alone and the organizational forms described in the IOR literature do not specifically contemplate complex, cross-sector R&D collaboration. Conversely, the analysts who have pointed to the emergence of socially-focused cross-sector R&D have paid insufficient attention to how these activities are actually organized. Table 1 therefore attempts to characterise the structure and activities of the CRCs in organizational terms. CRCs are clearly *hybrid organizations* in the sense that they are neither hierarchical (common ownership) nor closely market driven (by market oriented contracts). Some but by no means all CRCs carry on commercial activities either as part of their core function or through spin-off companies and therefore ‘combine’ profit and non-profit activities. All envisage eventual application of their R&D through the centre partners or in some other way. They are certainly hybrid in Menard’s sense because they involve contractual relationships between legally independent partners. They represent the coming together of several organizational forms – commercial firms, universities and government research agencies. One would therefore expect them to adopt characteristics and ‘cultures’ from each of these ‘functional domains’. They are also public-private partnerships, and this observation is helpful in that explains why they should not be wholly market driven. They bring into being a new organization (the CRC itself) which has a separate legal identity and are therefore somewhat akin to JVRCs. Up to a point they are centrally coordinated, but the way they recruit members is more akin to a cooperative!

### *Management issues*

The value of this approach is that the issues that arise in the management of inter-firm hybrid organizations or IORs in general may be presumed to apply by extension to cross-sector R&D

collaboration. From Table 1 we selectively consider four groups of issues which we hypothesise are important in the management of cross-sector R&D.

**Table 1: Selected organizational models and their application to Cooperative Research Centres**

Type of Organization	Characteristics	Applicable to CRC?
<b>Hybrid organization</b> (Lamb and Davidson 2004; Menard 2004; Minkoff 2002)	• Autonomous, legally independent partners	√
	• Contractual framework	√
	• Between hierarchy and market	√
	• Combine 'profit' and 'not for profit' functions	?
	• Multiple functional domains	√
<b>Virtual organization</b> (Handy 1995, Hatch 1997; Holland and Lockett 1998; Jarvenpaa and Leidner 1999)	• Geographically dispersed	√
	• Technology-mediated communication	?
	• Behave as single entity (sometimes)	√
	• May or may not have contractual framework	X
	• All activities outsourced	X
<b>Private-public partnership</b> (Hagedoorn et al. 2000)	• Public and business sector participants	√
	• Public and business funding	√
<b>Network/ Network enterprise</b> (Castells 2001)	• Reconfiguration of network for each business project	X
	• Coordinated decision making and decentralised execution	√
<b>Cooperatives</b> (Handy 1993)	• member-based	?
	• 'the person culture in organizational form'	X
	• Democratically controlled.	X
<b>'Mode 2' hybrid research community</b> (Gibbons et al. 1994; Nowotny et al. 2001)	• People socialised in different sub-systems	√
	• Learning different styles of thought, behaviour, competence	√
	• Combining scientific disciplines	√
	• Not centrally planned or coordinated	X
<b>Joint Venture Research Corporation (JVRC)</b> (Hagedoorn et al. 2000)	• New 'child' organization combining knowledge and resources of partners	?

Note: √ = Applicable; ? = Partly applicable or applicable under some circumstances; X = Not applicable

**Benefits and costs.** The notion of competition means that if voluntary cooperation is to arise and be sustained, all participants must see some benefit that they could not achieve more easily alone or in some other way otherwise there is a 'credible threat' of unilateral action e.g. that he/she will unilaterally withdraw (Oster 1994: 247). How can partners assess and monitor

the benefit in cooperative R&D, which given the nature of activity may be intangible and long-term?

**Trust.** The notion of risk and trust in IORs is well expounded in the literature. Holland and Lockett (1998: 606) describe the coalescence of virtual organizations around outcomes and the need to deal with the risk that the outcome may not be achieved: ‘there is a significant level of risk associated with the outcome ... and organizational trust has been hypothesised to be an explanatory variable for the development of such cooperative behaviour’. Academic science is built on trust in the quality and validity of research performed which is ensured through public sharing of knowledge (Liebeskind and Oliver 1998). The encroachment of commercial goals presents risks to the culture of ‘open science’ (Liebeskind and Oliver 1998) and brings the interests of the individual academic and the university into potential conflict (Ziman 1991). As we note elsewhere, ‘To engage in science in this context, as either manager or researcher, engages one in a struggle between the organizational forms that seek to own and gain economic benefit from investments in science and the working practitioners of science’ (Turpin et al. 1996: 271). How are partners selected and how do participants assess trust and reputation (and its breach); how is trust built and the risk reduced of opportunist behaviour between the independent partners?

**Governance and coordination.** As Nooteboom (2000) points out, one of the reasons why inter-organizational networks encourage innovation and learning is by bringing together people with a greater ‘cognitive distance’ (CD) between them. It is likely that the CD of researchers from different organizations will be greater than those within an organization. A strength of the CRCs is therefore to bring together multiple partners with different organizational and disciplinary backgrounds and perspectives. A large CD has the merit of novelty – bringing in new ideas – but brings with it the problem of incomprehensibility. The partners will have different views not just about the science of the project, but, as Gibbons et al. (1994) point out, also what constitutes legitimate competition, reward and ‘fair play’. A central task of the CRC is therefore to achieve some form of coordination - a set of ground rules – for the collaboration. What is the appropriate balance between trust and ‘formal government’ (Menard 2004) required to coordinate complex hybrid cross-sector R&D organizations? What ‘governance’ and rules are accepted and enforced? What is regarded as legitimate competition, collaboration, ownership, reward or ‘fair play’? How are objectives and strategies defined and implemented (Steenhuis and Gray 2006)?

**Functional domains and cultures.** Rather than seeing CRCs as a form of compromise between research and commercial activities, a better view is the notion of working in and across several functional domains. Gibbons et al. (1994: 48) argue that universities and government laboratories have entered ‘the game of dynamic competition’, where ‘knowledge resources are held in different organizations and can be shifted between environments which are at one moment competitive and at another collaborative’. These environments are not discrete, but are populated by actors who ‘move back and forth’, for example, researchers who work concurrently in a university department and a CRC. Nowotny et al. (2001: 106) talk about hybridization in the sense of combination of scientific disciplines and multidisciplinary. This allows the idea that different functional domains (which others might term sub-cultures) can exist *within* and *across* the partner organizations as well as *between* them. As Ziman (1991: 45-47) shows, universities are quite unlike firms in this regard because of their highly segmented components – departments, research centres etc; and the ‘blurred line’ between academics acting as university staff and performing as independent entrepreneurs. There are many ways in which the activities and behaviours of these various ‘functional domains’ can potentially meet, overlap and compete or conflict. The centres bring together participants who are used to working in quite different ways, potentially giving rise to difficulty in understanding or tolerating other behaviours. Individual researchers may learn to operate in new ways while in the CRC and this may divert them from their role in their ‘home’ organization. By bringing together different functional domains within the same participant organization (e.g. scientific disciplines) the centre may provoke competition between them for resources or reputation.

We use the findings of a survey of CRCs to assess whether these issues have arisen, how significant they are and examine how they have been addressed. In this way we attempt to identify those areas where cooperation has the potential to turn to competition.

## **Methods**

The results reported in this paper are selected from a written ‘Research Culture’ survey of 370 respondents from public sector organizations involved in the management and conduct of collaborative R&D in the CRCs. The written, mixed-mode (postal and web-based) survey covered a non-random but representative sample of those involved in the management and

conduct of CRC based research in public sector organizations. Respondents comprised researchers and research managers from 37 CRCs, most of whom were involved directly as a formal participants. The survey achieved a 34% response rate: of the 1099 questionnaires distributed, 370 individuals responded. The majority (53%) of respondents identified themselves as from the Higher Education (HE) sector, with 21% from the Government Research (GR) sector the remainder were employed directly by a CRC, by another government agency or other organization. The respondent set was quite homogeneous: 82% of the respondents were men; while about 77% held a doctoral degree and a further 11% a masters degree. Two-thirds of the respondents participated in one CRC only, while the rest were involved with 2-7 CRCs.

The survey questionnaire presented 48 propositions about the respondent's experience with the CRC program under four headings: the benefits of CRC participation to the respondent and their organization; the problems encountered; the management strategies adopted for participation; and the effect of CRC participation on research training and career structures (see Table 4). Respondents were invited to rate each proposition on a six-point Likert scale. The final question (optional) in each section allowed an open-ended response to each theme. Of the respondents, 209 or 57% chose to respond to one or more of the optional questions. Their characteristics were almost identical to the full respondent group in terms of their gender, highest qualification, length of time with the CRC and where they were employed (Table 2).

Statistical analysis of the Likert scores for each proposition was performed using SPSS 13.0 while the qualitative responses were analysed with the assistance of the QSR NVivo 2 software. A summary of the median responses to each proposition is given in Table 4. While we use these results to judge how widespread particular views are the current paper concentrates on the respondents' qualitative responses to the four open-ended questions.

**Table 2: Employment sector of survey respondents**

<b>Sector of employment</b>	<b>CRC</b>	<b>Higher Education (HE)</b>	<b>Gov't Research (GR)</b>	<b>Gov't other</b>	<b>Other</b>	<b>Total</b>
No. respondents	34	196	78	43	19	370
% of respondents	9.2%	53.0%	21.1%	11.6%	5.2%	100.0%
No. respondents answering open-ended questions	18	108	45	23	12	209
% of respondents answering open-ended questions	8.6%	51.7%	21.5%	11.0%	5.7%	100.0%

### **The views of CRC participants**

The responses of the public sector participants in the CRCs to our ‘open-ended’ questions provide a fascinating snapshot of their views on a range of issues. While we asked specifically about the benefits, problems, administration issues and impact on career of respondents’ participation in the CRC, respondents did not seem overly constrained by these headings! In the following sections we examine the opinions of respondents on the intersecting issues of benefits and costs, governance and coordination, trust and competition between functional domains.

#### *Benefits and costs*

Predictably, respondents saw strong benefit in membership of their CRC. Indeed some were effusive: ‘My association with the CRC has been extremely beneficial and rewarding and I can think of few downsides to my participation in the CRC’ (ID-358); ‘it is one of the best things that has happened for me’ (ID-61).

The CRCs certainly provide material resources. Respondents nominated ‘money for continuing research activities - the chase for the dollar!’ (ID-343) with ‘greater stability and longer-term funding’ (ID-337) than available elsewhere; for particular research activities such as ‘opportunities for conference attendance/workshop participation not otherwise supported by my organization’ (ID-356); funds for staff and ‘generous PhD scholarships’ (ID-90). ‘[I] got a real good (well two) student PhDs’ writes ID-311.

Most benefits identified were intangible and came from the partners in the CRC, rather than from the CRC itself. Comments praised the value of relations with researchers in their own field: ‘working with peers from other organizations whom I respect’ (ID-118); ‘Membership in a group of otherwise disparate scholars’ (ID-65); ‘A spirit of belonging to a broad research community’ (ID-333); a ‘Widened fraternity of scientists with similar interest/goals’ (ID-263); or simply ‘Access to ideas’ (ID-307). These contacts were either unavailable through their organization alone, ‘Contact with colleagues that I would otherwise not have enjoyed’ (ID-255) or more difficult to arrange:

‘...Opportunity to work within a team with similar research interests and opportunities for cross-fertilisation and collaboration with other researchers. If I weren’t associated with the CRC I would be working mostly in isolation.’(ID-222)

In short, some researchers saw a significant cost in *not* being part of a CRC as it provided an otherwise missing element to the respondent’s ‘scientific context’.

Not only did the CRC embed the researchers in their peer groups, but it helped them to broaden their research perspectives through interaction with scientists working in other disciplines. The ‘Project has exposed me to other ideas and disciplines - very positively’ (ID-237). It ‘opened up my eyes to a different approach to research’ comments ID-278. Another valued:

‘involvement within an interdisciplinary team of researchers...broadened my knowledge base and made me feel more appreciative of the research from other disciplines and how it and my own research complement each other.’ (ID-59)

Several respondents commented on ‘closer relations with industry’ (ID-152) and provision of a business or commercial focus for their research: one gained a ‘Wider view of my research area, especially with respect to application of results in industry’ (ID-140).

Many benefits nominated by respondents were directly related to their own careers and capabilities. From basic employment: it ‘gave me a job’ (ID-225), ‘Helped to keep me employed’ (ID-192), to assisting with ‘career progression’ (ID-134); ‘Greatly increased scope and confidence of use in applying for senior jobs’ (ID-272); or other personal goals: ‘Promised opportunities to remain in a rural town’ (ID-176) or ‘Spin-off company giving broad experience and consulting work post-retirement from the university and CRC’ (ID-126). Comments related to research field or focus: ‘Helped increase research focus’ (ID-144),

allowing one respondent '[t]o continue to undertake research in the same field as that for my PhD' (ID-160). For another, 'Networking and identification of other commercial/clinical areas have re-focused my research career' (ID-229) or 'Facilitate working in applied research' (ID-166). Involvement with the CRC led to new personal skills, notably in management and leadership: 'allowed me to fulfil or expand scientific management aspiration'. (ID-345); 'Better understanding of IP management and commercialisation' (ID-360); and 'Got me to work more efficiently (to meet deadlines)' (ID-312).

Benefits for research groups within the partner organizations were also identified. CRC involvement provided a 'Means of uniting the interests of departmental members who would otherwise have quite disparate interests' (ID-215); and the 'program gives a strong strategic focus for a major research group in [my organization]' (ID-231). Status and recognition within the organization has resulted: 'a useful lever to get better support within my organization'. (ID-138); and 'The CRC has increased my visibility among peers and industry partners' (ID-114).

In summary, the benefits identified by respondents in their answers are varied, but overwhelmingly they relate to the domain of 'science' and the quality of the research they, personally and within their immediate research groups, are able to do. They value the improvement in their interaction with the scientific community; they value the perspectives that researchers in other disciplines and institutions bring to *their* research; they value the view of 'different ways of doing things' that interaction with commercial firms gives to *their research*. They are closely aware of the personal benefits to them as career researchers, for continuing the kind of work they find productive, extension of their skills and career prospects, and their standing within their institution and the scientific community. While they value the cohesion that the focus of the CRC work gives to their research group or department, they rarely express benefit in terms of advantage to their organization *per se*. In terms of our classification of risk, their perspective of benefit is almost solely on the 'scientific' and 'academic' domains.

As participation in the CRCs is intended to be voluntary, the individual researcher and their 'home' institution must weigh up both the perceived benefits and costs of engagement with the CRC. Unless net value is perceived there is a 'credible threat' of unilateral action e.g. that he/she will withdraw or start to act opportunistically. The 'science based' view of the benefits



also influences our respondents' views of the costs of participation. Broadly, anything which distances them from the network of high quality researchers or diverts them from their own research is seen as a cost. These costs emerge in looking at the ideas of trust and competition.

### *Trust - Competition between partners in the CRC*

First we consider the two elements of what Nooteboom (2000: 918) calls 'the slippery notion of trust'. These are *competence* (or the capability to deliver the agreed outcomes) and *intention* (the degree to which parties are committed to the avowed goals and avoid opportunism, i.e. putting self-interest above the goals of the centre). Second we consider forms of competition and conflict that are perhaps peculiar to cross-sector R&D collaboration and which relate to the nature of the research organizations involved in the collaboration and context of 'science' itself.

Both trust in competence and trust in intention are important in the minds of our respondents when describing problems with their partners in the CRCs. Competence expresses itself particularly in respondents' assessment of the quality of the researchers in the collaboration:

'Inconsistent calibre of researchers - the CEO was not in a position to tell research agencies that their researchers were inappropriate (because of their skills or performance). ... the CRC had to adopt a 'lowest common denominator' approach. It was slowed down by its weakest members'. (ID-100)

This can result in 'a lot of "B" researchers doing quite limited work' (ID-7) in the view of another respondent. 'Company members supply their second-level staff' (ID-121), observed another. Initial selection of partners is crucial in any IOR and yet in at least one case a respondent comments the quality of the researchers was not the overriding consideration:

'The university with the most knowledge may not necessarily be working on the project. Who is doing the work is more likely to be the uni[versity] that initiates the proposal' (ID-37).

Respondents also identified partners as unable (rather than unwilling) to manage themselves or to deliver appropriate inputs rather than lacking in scientific competence: 'Lack of vision by industry partners' (ID-369) and '[v]ery little feedback on the adoption of research outcomes by industry/partner agencies/stakeholders' (ID-148) were two comments. Criticising a particular government agency one respondent claimed:

'[named agency] is the bureaucracy-laden, meetings/talk fest focussed organization, not the CRC; CRC staff are too busy doing what industry actually wants and thereby get another term to waste the amount of resources [named agency] staff do' (ID-160).

Generally, however, failings by other partners resulting in '[c]ompetition at the expense of collaboration' (ID-199) were interpreted in terms of the party's self-interest and lack of commitment rather than their incapacity: 'Some institutions are NOT 'co-operative'' said one (ID-253); 'Certain individuals from other academic institutions forgetting that the first 'C' stands for cooperative' (ID-79); 'Failure of some researchers to collaborate openly and fairly' (ID-386) commented others. Both individual participants and organizations are nominated as opportunist:

'The participants ... should think about the aim of the CRC carefully and should make stronger efforts together to achieve the main aim. I feel that both researchers and the industry are rather selfish in trying to maximise their own gains and not acknowledging each other's needs and goals' (ID-266).

Again, 'Researchers, especially in [nominated agency] and universities, have got to learn how to cooperate rather than compete. This issue also applies institutionally in some cases' (ID-272).

In summary, respondents lose faith in their partners when they are viewed (1) as poor quality researchers, (2) when they are viewed as incapable of delivering knowledge, results or feedback, and (3) when they seem to lack commitment to the ethos of cooperation or are perceived to be pursuing their own ends.

What leads to this lack of trust? Two factors commonly mentioned are (1) inadequate commitment of resources (people and money usually) either actual or perceived (or unverifiable) and (2) domination of or undue influence on the direction of the collaboration or of the potential rewards. The way that CRCs are structured makes it difficult for partners to assess whether each other is 'pulling their weight'. 'Costing models between partners are wildly different and project budgeting is a major source of mistrust' says (ID-96). Reneging on commitments is viewed seriously: 'Ensuring in-kind contributions match commitments' (ID-184); 'Multi-partner programs are unwieldy when [the] percentage commitment of individual staff is low (<30%) and over-ridden by host institution priorities' (ID-89). 'Inflexible and one-sided IP arrangements' (ID-123) are also viewed with distrust as a form of self-interest.

So the factors contributing to the maintenance of trust *between partners* appear similar to other IORs, but is made more difficult by the inherently unspecifiable nature of R&D outcomes and difficulty of assessing the actual level of resources (particularly ‘in-kind’ staff time) actually being committed by the partners. The actions that seem to be regarded as most trustworthy are being able to carry out quality research, exchanging information and knowledge, executing agreed tasks and generally being accommodating and ‘cooperative’ to other partners.

### *Competition between functional domains*

#### *a. Competition between the CRC and the ‘home organization’*

Both issues are compounded by the fact that researchers are generally committed only part time to the CRC and remain based in their ‘home’ organization – their university or government laboratory. This can lead to divided loyalties and to competition for resources between the work of the CRC and the work of the parent organization. Not surprisingly this leaves researchers confused and stressed: ‘Divided loyalties are an issue - particularly with long running CRCs’ (ID-96); ‘With [nominated] CRC, [it is] difficult to know who is the master, the CRC or the [nominated partner]’ (ID-55). As one respondent expressed it,

‘When is a researcher doing it as a ‘CRC project’ versus their organization’s project? - Grey line. CRC in-kind staff not acknowledging the CRC in their papers, email ..., publications. In other words their host organization always dominates the researcher priority as that is who promotes and pays them’ (ID-367).

‘Interaction with parent institution’ (ID-134) and ‘an inherent problem of split loyalty between the employer and the CRC’ (ID-140) are identified as problems by a surprising number of respondents. Researchers have chosen to work with the CRC and expect their employer to support them in this choice and their trust is eroded if the employer does not. One respondent complains that ‘My university/school has not honoured my in-kind contribution to the CRC’ (ID-59). Another observes ‘I was a program leader in the CRC. I don’t think I was properly supported in the role by my own organization’ (ID-100).

Having two masters makes it harder to work within the CRC framework than on projects which are less complex in structure, as one government researcher observes:

‘It is a constant challenge to meet the multi-layered management requirements of both [the home organization] and the CRC. There is potential for both conflict and administrative overload, which makes CRC participation significantly harder work (albeit rewarding) than simply working 100% on [the home organization] projects’ (ID-231).

Another government-based respondent interprets this as losing control of the project:

‘organizational commitment to allowing time (i.e. having time left over from other organizational duties to dedicate to CRC projects) which means much of the running of the projects is necessarily left to university researchers’ (ID-112).

Several potential sources of conflict may be identified. The first is competition for resources – primarily researchers’ time. Researchers feel pulled between their ‘regular job’ and their commitment to the CRC: ‘Meeting deadlines due to ‘normal’ core commitments’ (ID-176); ‘Too much of my time spent in managing researchers and contracts for the CRC’ (ID-313); ‘It is difficult to find sufficient time for ‘proper’ management of projects and for ‘proper’ research’ (ID-342). At its extreme, if poorly managed, this competition for resources can affect researchers who are not affiliated with the CRC giving rise to competition within the partner organization:

‘The CRC research and time commitments done by faculty in our school who have contract agreements, is being subsidised by other faculty. This is because no [money] was given to the school to cover the teaching and administrative responsibilities of these faculty members. It has led to a major rift within our school and has severely impacted the ability of non-CRC committed faculty to engage in research’ (ID-242).

The second conflict is between the ways that CRC acts and the practices and norms of the partner organizations. In one case a respondent characterised this as a ‘Clash in management ethos between CEO and the practice of the participating organization’ (ID-72); another accused the CRC of ‘[i]nterfering with management structures of other parties’ (ID-360). This may be in communication, timing of activities, accepted protocols for supervision of research students etc: ‘One-year projects insufficient for hiring staff, can’t complete work, expenditure and reporting within the year, and CRC on financial year clashes badly with academic year (trying to complete projects right at end of first semester!)’ (ID-185). ‘Main work force in CRC derived from PhD. students. This leads to a conflict between research and commercial priorities. Students need to do work to complete their PhDs whereas industry is focussed on producing products’. (ID-19) ‘Some CRC’s dealing direct with researcher and students and NOT through the Uni[versity] research office’ (ID-162). In one case the:

‘CRC attempts to control P/G students with no regard to supervisors. We were invited to participate and contribute to the CRC by the Board, but CRC management have ignored and refused our participation. However they wanted our P/G students and wanted to own them with a small financial contribution to their research (an incredible attitude!)’ (ID-355)

The third competitive element is between the work of the CRC and the reward structures of the partner organization. This can have a direct and immediate effect on the career of the researcher if the researcher’s service is not recognised by the partner organization:

‘When my contract with [nominated agency] expired ...I had worked for the organization [for more than 7 years]. However, I was advised I was ineligible for ‘indefinite’ appointment because I had been a CRC associate employee for most of this time! So no, I got no benefit from being a CRC employee with [nominated agency].’ (ID-160)

In many cases then, ‘researchers in CRC do not have clear career path’ (ID-316). Often, the impact is more subtle. ‘The research success of an employee in a CRC project may not necessarily be properly acknowledged by the employer’ (ID-140). One respondent, seconded to a CRC at a senior level, found a ‘complete disjoint between performance appraisal by my employer and my actual work in CRC’ (ID-360). While another respondent welcomed ‘funding for students’ as a benefit, they noted that ‘regrettably [the funding] does not go through university channels so does not count for Research Quotient’ (ID-325) and thus did not earn matching funds from research block grants.

Conversely, the requirements of the CRC may prevent or stifle peer recognition of the researcher either by their employer, or in their wider scientific peer group. Two areas identified were (1) constraints on free publication and (2) access to prestigious research grants from bodies such as the Australian Research Council (ARC). ‘Writing of papers is difficult’ (ID-361) commented one respondent while others mentioned ‘publication restrictions’ (ID-253) and ‘delays in publishing while CRC makes decisions about IP protection’ (ID-214). ‘Ineligibility for ARC funding’ (ID-365) was hard felt. ‘[T]he centre existence stops ARC applications’ (ID-361) and ‘[m]akes attainment of other ARC funding difficult or impossible. (ID-335). This potentially hampers recruitment to the CRC and collaboration with researchers outside the CRC:

‘Academics on ARC funding [are] very unwilling to collaborate lest ARC and CRC support is seen to mix - a number of very exciting and important collaboration opportunities [were] lost as ARC funded researchers were unwilling to ‘risk’ their ARC support by taking benefit from CRC projects’ (ID-123).

One university researcher lamented:

‘The CRC has had serious negative effects for me. Because my project became highly confidential I cannot publish any results on major research innovations. The project is finished and I now have no grant money, no research staff and no publications. The short-term objectives of the CRC are destructive for an academic career’ (ID-26).

*b. Competition between the domains of science and commerce*

As CRCs bring together research and commercial interests, it is not surprising that a further, potential field of competition within the CRC is a more philosophical clash between the rationale of CRC and its industry partners and the norms of ‘science’. This may not adversely affect immediate rewards, but in some cases researchers clearly felt uncomfortable about the direction of the CRC and the balance of its activities. Comments on particular CRCs included: ‘Too much emphasis on commercial outcomes and not enough emphasis on research’ (ID-136); ‘Lack of scientific vision - short-term objectives prioritised’ (ID-268); ‘Suppression of truly innovative basic research’ (ID-152); or conversely the view that ‘Some academic researchers biased against ‘applied’ CRC research’ (ID-123). Criticism was also made of the program as whole:

‘I am concerned by the trend away from Public Good CRCs to business style CRCs’ (ID-176)

‘If the Science is left out in favour of commercialisation issues I believe the image and product of the CRCs will suffer considerably’ (ID-112).

*Governance and coordination*

The role of governance is to resolve these differences and to unite the CRC around agreed strategies. There is also an obligation to report to the partners and the funding agency on research projects and outcomes.

Perhaps surprisingly, many respondents regarded these activities as unnecessary costs and as far more onerous than with alternative forms of research support. ‘Transaction costs are very high’ (ID-230) was a typical response when asked about problems with the management of the CRC. ‘More forms, more paperwork, more reviews’ (ID-125); ‘There is a large administrative cost linking different institutions’ (ID-141); ‘I was frustrated by how cumbersome the CRC was’ (ID-100) ‘Dual reporting needs’ (ID-164); ‘Compared to an ARC grant, a CRC has a much greater administrative cost and suffers from the possibility that the

funds can be altered through the life of a project' (ID-141) is a selection of comments from other respondents.

Why do respondents find these transaction costs so frustrating and burdensome? First, they see little benefit flowing back to themselves or their research groups: 'Unnecessary forms, timesheets etc. with no management feedback even to project leaders; so seems pointless' (ID-121). Second, the politicking and management distracts them from their main concern of carrying out research: 'Massive percentage of funds spent on administration rather than research' (ID-335); 'The CRC reporting requirements strongly impinge upon research time and activities' (ID-3). 'Too much money spent on 'organization' - meetings etc ... Not enough for research. CRCs should be about research' (ID-200); 'Focus is not on research' (ID-254).

'There are problems in research management of the CRC. There are too much politics involved. It is often the case that a small number of researchers have taken too much responsibilities [*sic*] in research than they can handle. Yet, those researchers spend more time in playing politics than doing R&D. The researchers who are doing the groundwork haven't been given enough opportunities so that they often lose reasonable independence, resulting in low efficiency, poor effectiveness and performance in the real R&D' (ID-103).

Respondents also found the CRCs cumbersome in other activities: 'Slow processes with regards to commercialisation, licensing and marketing' (ID-146); 'The CRC is not responsive. Timelines for delivery of results of constrained by academic processes' (ID-27).

The quote from ID-103 above alludes to a further issue with CRC governance. The respondents expect a strong say in the strategy and running of the CRC; they are unhappy when they are not consulted and informed: 'We get told what to do! Too little funds! A lot spent on management!' (ID-264) as one respondent succinctly put it; 'If you can capture the Centre, you are provided for; if not you are marginalised' (ID-339); 'Autocratic leadership; high staff turnover; lack of communications; lack of transparency on employment of researchers' (ID-16) were listed as problems. 'I do not have much say in the affairs of CRC. I know I have the capacity to contribute more but no takers' (ID-31). One respondent had difficulty in '[k]nowing quite where I and my students fit in' (ID-349). Another respondent was annoyed about '[a]rbitrary decisions to reduce committed funding to enable [external?] "communication"' (ID-127).

‘This is a not a collaborative organization - research funding is not distributed on the needs of the CRC rather the inlaid commitments of the participants - to the detriment of the scientific and engineering outcomes - internal politics rather than rational assessment of priorities determines resource allocation... A lot of time has been wasted in useless and fruitless discussions I could well have spent on other research projects’. (ID-343)

There are two ways of looking at how cooperation can be ensured (i) a social theory approach – reciprocity, mutual forbearance, relational trust (based on experience); and (ii) using transaction cost economics – with the concept of opportunism (not acting cooperatively), and monitoring of performance, sanctions (legal punishment, penalties etc) (Handy 1995; Menard 2004; Nootboom 2000). While the level of reporting in the CRCs might imply the latter approach, in reality any form of imposed sanction was viewed by respondents most unfavourably. In one instance the researchers felt ‘railroaded’ into the CRC by their university and into neglecting their ‘real’ job:

‘Many of us were put in the [nominated] CRC by senior management without any discussion in order to meet FTE [full-time equivalent] targets shown in the proposal. Most of us were not even aware of the proposal, nor asked if we wished to be involved. Attempts to be removed from the [nominated] CRC were met with threats of dismissal. Time spent on CRC projects (unfunded and by edict of university management) has reduced my research productivity and caused significant increased workloads (and stress).’ (ID-122)

What implications do these views have for the governance of CRCs? While the collaboration is contractual (between the legal entities), its implementation and enforcement at the level of the department and individual researcher appears to be informal. Respondents were clearly expecting reciprocity in degree of commitment and expertise, provision of resources and information, forbearance of different ways of working, and an absence of opportunism. Any evidence of a breach caused respondents at very least to become less enthusiastic about the Centre, and at the extreme to quit the CRC. Monitoring of performance would help identify breaches, but there are few sanctions that could be applied on one partner by another. The only sanction therefore is to withdraw, or to threaten to withdraw from the current or future collaboration thus breaking the durability of the relationship.

Cooperative centres are not ‘cooperatives’ in the sense of being member-based, democratically controlled organizations. But they start this way, recruiting voluntary participants in the bid for grant funding. In terms of Handy’s four organizational ‘cultures’ (power/role/task/person) they start as a ‘person culture’ and move into a ‘task culture’ once



goals are agreed and funding achieved. In Handy's description, a task culture 'is a team culture, where the outcome, the result, the product, of the team's work tends to be the common enemy obliterating individual differences'. The problem arises when resources have to be rationed. As Handy observes:

'top management then feel the need to control methods, as well as results. Alternatively, team leaders begin to compete, using political influence, for available resources. In either case, morale in the work-groups declines... so that individuals begin ... to reveal their individual objectives ... In short, the task culture tends to change to a role or power culture when resources are limited or the total organization is unsuccessful. It is a difficult culture to control and inherently unstable by itself' (Handy 1993: 189).

In a single organization, significant constraint on individual's resorting to opportunist behaviour may exist – loss of position or employment for example. There is also a single top management to impose, if necessary, adherence to organizational strategies and goals. But in CRCs the story is even more complicated because it is an inter-organizational network. Thus it is easier for researchers in a CRC to revert to a 'person culture' where they view the organization as existing largely to allow them to pursue their own interests which may indirectly benefit the organization (Handy 1993).

The consequences for the CRC are fairly obvious. One respondent suggest that 'evasion' takes place:

'The requirements of genuine collaboration cause many researchers some pain as they are often looking for academic freedom. In some cases, the CRCs message as conveyed by the CEO, the Executive Research Committee and the relevant program coordinator has been effectively ignored by project leaders (who have been protected by their institution's management)' (ID-231)

'Exit' is an option too, less for the partner organizations (because of contractual commitments) than for the individual researchers. I '[d]ecided not to participate in other CRCs' (ID-259) wrote one respondent, and this sentiment was echoed by others:

'It has clarified my directions - I never want to work with one again. It has also discouraged me from conducting applied research' (ID-155).

'[M]y attempts to maintain an external collaboration tore me apart (double management reporting presentation etc) so much that I am leaving this job with the CRC to take a regular funded position overseas with clean and simple funding provided + 30% salary increase' (ID-52).

At the organizational level, selective exit was considered:

'They are one of the lowest priority sources of external investment due to the level of internal investment (staff resources and cash) required to achieve/match with CRC cash. If it weren't for the

additional industry investment made in the CRC we would have probably withdrawn totally from the CRC by now. Some projects were withdrawn from the CRC so that a higher level of external investment and low level of encumbrance could be achieved' (ID-328).

If we can validly summarise such diverse views then the message from our respondents might be: 'CRCs should be truly cooperative, CRCs should be about research'.

### **Conclusions – competition in cooperation**

We conclude that the arrangement of cross-sector R&D collaboration embodied in CRCs is an inherently unstable organizational form for two broad reasons:

1. First is the heterogeneity of the culture and functional domains involved, the tensions between them and the potential for competition and conflict. Our survey shows that many of the participants will not accept a high 'power distance' and expect to be allowed to behave in an 'individualistic' manner (Hofstede and Hofstede 2005) in relation to their scientific creativity.
2. Second is the problem of coordination in a multi-institutional environment where the partners and individual researchers essentially remain free-agents, despite contractual commitments to the CRC.

While each of these factors may well exist in inter-firm IORs, we suspect that they are substantially greater in cross-sectoral R&D collaboration.

Some sources of competition are more strongly felt by our respondents, most of whom are research scientists. The competition that is most immediate seems to be that of their own career – how they are able to perform their research, their conditions and rewards, their prospects. The respondents tend to see the benefits of the CRC firstly in terms of advantage to their own research career and secondly in terms of the 'scientific' context in which their career resides. They regarded as a cost or a burden anything (administration, reporting, short-termism, constraints on publication) that diverts them from their research career. But at the same time the presence of commercial partners and the government's goals for the CRC program itself impose a commercial imperative on the collaboration.

Because of this focus on science and career, we consider it is inadequate just to look at the motivation and commitment of the partner organizations alone. The resource-based view of

the firm emphasises the need for management processes to consider the key resources of CRCs – the researchers themselves and the intangible assets of knowledge and creativity. The management and organizational studies literature emphasises four types of risk management: ‘strategic risk’; ‘financial risk’; ‘managerial decision making risk’; and ‘project management risk’ (Baird and Thomas 1985; McNamara and Bromley 1999). In managing cross-sector R&D organizations we see a need to link and extend these perspectives by adopting the following categories of ‘risk’ which recognise different functional domains:

- *Academic risk* is the risk experienced by individual researchers in their role as employees, such as the effect on opportunities for career advance and mobility.
- *Scientific risk* refers to the risk of change in the disciplinary structure of research and the organizational domains within which the disciplines are located e.g. university departments and centres.
- *Organizational risk* concerns the tension at the interface between the structure of cross-sector networks and the structure of the organizations in which they are embedded.

For example if we consider the management problem of ‘threat of exit’ we need to recognise that this ‘threat point’ can occur at different levels. It is possible for a researcher (academic level) to decide to or threaten to withdraw from CRC participation even though continued participation may be to the benefit of his/her discipline (scientific) or lab/university (organizational).

In Table 3, we speculate on the possible relationships between the forms of competition we have identified from the survey and sort of risks that the CRCs and their partner organizations face. We have not ‘filled in the blanks’ – this would require in-depth case studies of particular CRCs – but propose that this matrix can be used both to identify potential management issues and to analyse the management responses of successful CRCs.

**Table 3: Possible relationship between competition and risk in CRCs**

<b>Competition</b>	<b>Academic</b>	<b>Scientific</b>	<b>Organizational</b>
Between partners in the CRC			*
Within partners for resources			*
Between the program of the CRC and norms and reward systems of the partner organizations	*		*
Between the program of the CRC and norms and reward systems of science	*	*	
Between the domain of science and the domain of commerce		*	
Between alternative career paths	*	*	

### **The durability of cross-sector R&D centres**

A final question which remains unresolved is ‘how durable are cross-sector R&D organizations?’ On the one hand, this form of organization is becoming more dominant, and on the other the collaborations need to remain flexible and responsive with ‘ceaseless reconfiguration of resources, knowledge and skills’ (Gibbons et al. 1994: 47). We did not make a longitudinal study of particular CRCs, although we were able to contrast the views of researchers who had been associated with the CRC program for shorter or longer periods. There was some evidence that researchers who had been with a CRC for a quite short or very long time were more committed than those involved for an intermediate time.

We use two approaches to speculate on why this might be. First, in terms of the competitive pressures identified earlier and the competitive environment in which they reside; and second in terms of the theory of hybrid or networked organizations more generally.

Gibbons et al. (1994: 55) make the point that competition can only be understood as dynamic process, as a ‘race’ in which all elements - competitors, rules and criteria of success or failure - are evolving. Thus ‘dynamic competition’ is an explorative process aimed at generating resources (knowledge) in contrast to what Gibbons (2000) calls ‘static competition’ around re-allocation of existing resources. Increasingly universities and other research agencies are being drawn into the arena of dynamic competition between businesses. Consequently, as (Gibbons 2000: 356) further notes, the triple helix (Etzkowitz and Leydesdorff 1997)

‘envisages shifting patterns of interlinkage between universities, industry and government’, in other words a dynamic process involving reorganization.

As we suggest, managing an organization like a CRC requires recognition of the needs of the different functional domains and the competitions that they provoke. It also requires a balance between cooperation and cohesion (which to some extent implies control). CRCs start as cooperative bids, but must develop more cohesion and coordination to be effective. The problem, as Nooteboom (2000) observes, is that if networks are too cohesive they may become exclusionary, and if too durable they may create inertia. They may be very effective for particular well defined tasks, but lose flexibility and ability to change. At the extremes, two scenarios may play out in the life cycle of a CRC. First, (‘disintegration’) where the ‘ground rules’ are either too weak or not accepted or adhered to by all partners and individual participants, and the second (‘integration’) where the rules are so effective that they stifle change – maybe for good reason like a focus on commercial production.

CRCs in their current form are inherently unstable, and therefore ephemeral, arrangements. Is this a bad thing? – not necessarily. They embody many of the features of ‘Mode 2’ collaborative science with its flexibility and ability to respond to contextual changes in science itself and in the application of science. Indeed it may be counterproductive for individual CRCs to become entrenched. However, if the important role of cross-sectoral collaborative R&D centres is to be retained without damage to the science and innovation system as a whole the ‘academic’ and ‘scientific’ domains that we describe must be nurtured not eroded. This may also require new styles of management, both by the CRCs themselves and their participant organizations which recognise the knowledge resources – the scientific disciplines and careers of individual researchers on which they are founded.

**Table 4: Summary of responses to the survey propositions**

No	Proposition	Median Likert Score All respondents / (Significant difference at 0.05 level between HE and GR?)
C1	I am proud to be associated with the CRC.	Agree
C2	Involvement in the CRC improves the cohesion of my research team.	Agree
C3	The multi-centre model of the CRC enhances collaboration.	Agree
C4	My work associated with the CRC complements my other professional activities and responsibilities closely.	Agree (HE agree less strongly)
C5	The CRC provides a level of professional and administrative support not otherwise available from my organization.	Slightly Disagree (GR Disagree)
C6	The CRC gives me essential access to research facilities and equipment in the other participant organizations.	Slightly Agree
C7	CRC funds are an important source of external finance which my organization uses to leverage other funding.	Agree
C8	The commercial partners in the CRC give an important focus to my research objectives.	Agree
C9	The CRC is effective in producing commercial outcomes from intellectual property originating in my organization.	Slightly Agree
C10	Engagement in the CRC offers an avenue for bringing technology concepts to fruition that would be difficult to achieve by other means.	Agree
D1	The research objectives of the CRC are too strongly driven by the commercial partners.	Slightly Disagree (HE Slightly Agree)
D2	University partners have too much say in shaping the research directions of the CRC.	Slightly Disagree (HE Disagree)
D3	Industry participants in the CRC are too intent on short-term objectives.	Slightly Agree
D4	Industry led research projects in the CRC are not sufficiently challenging.	Disagree
D5	Commercial requirements for improved project management and agreed timelines are beneficial for researchers in my organization.	Slightly Agree
D6	I do too much development and not enough research in my involvement in the CRC.	Disagree
D7	My department/institution appears to be subsidising my involvement in the CRC.	Slightly Agree
D8	My conditions of employment (e.g. workload model, performance agreement) do not adequately reflect the time I need to devote to the CRC.	Slightly Agree
D9	It is difficult to change our level of commitment to CRC as circumstances change.	Slightly Agree
D10	There is too much competition between CRC staff and others at my institution.	Disagree
D11	The research objectives of the CRC have distorted research priorities in other parts of my organization.	Disagree
D12	I feel I have an appropriate degree of influence over decisions made by the CRC.	Slightly Agree
D13	My views are adequately represented on the CRC Board and its committees.	Slightly Agree
D14	The CRC is too bureaucratic.	Slightly Agree (GR Slightly Disagree)
D15	The CRC does not provide my organization with an adequate return on investment.	Slightly Disagree
E1	My organization has developed a specific management regime for CRCs.	Slightly Agree
E2	Performance measures adopted for the CRC have caused my organization to change the way it reports research outputs.	Disagree
E3	The CRC operates very much like a business.	Slightly Agree
E4	The CRC operates much like any academic department.	Slightly Disagree

No	Proposition	Median Likert Score All respondents / (Significant difference at 0.05 level between HE and GR?)
E5	The CEO is the lynch pin of the success of the CRC.	Agree
E6	Participants in the CRC need to be fully represented on the Board.	Agree
E7	The ability and experience of the individual Board members determine the CRC's success.	Slightly Agree
E8	There is usually consensus among participants in the CRC about strategic decisions.	Slightly Disagree
E9	My colleagues in the CRC are more important to me than those elsewhere.	Disagree
E10	In my experience, CRC research projects are over-managed.	Slightly Disagree
F1	It is productive for postgraduate students to be supervised jointly by academic and industry researchers.	Agree
F2	It is productive for postgraduate students to be supervised jointly by academics and researchers from government research organizations.	Agree
F3	In general, postgraduate research projects in the CRC are quarantined from sensitive intellectual property.	Slightly Disagree
F4	The CRC finds it difficult to attract postgraduate students of the right calibre.	Slightly Disagree
F5	Graduates associated with the CRC enjoy better career outcomes than other graduates.	Slightly Agree
F6	My work with the CRC has enhanced my prospects for promotion within my organization.	Slightly Disagree
F7	My work with the CRC has enhanced my career prospects generally.	Slightly Agree
F8	CRC participation has improved the way I work with industry partners generally.	Slightly Agree
F9	CRC participation has been a positive influence in redirecting my research activities.	Slightly Agree
F10	CRC participation has reduced my interaction with students and research staff outside the CRC.	Disagree
F11	CRC participation has increased my opportunities for scholarly publications.	Slightly Disagree
F12	CRC participation has increased my potential for ARC / NHMRC research grant funding.	Disagree (Half of respondents in the GR group indicated that question was 'not applicable')
F13	The CRC has limited my opportunities to undertake long term or fundamental research.	Slightly Disagree

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