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Managing Risk in Cross-sector R&D Collaborations: Lessons From an International Case Study

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ABSTRACT *Cross-sector collaborations to perform R&D are on the increase, but they do involve various risks for each of the partners. Project risks in such ventures are explored through a case study, a successful collaboration involving an Australian Cooperative Research Centre and Ciba Vision, a division of the Swiss multi-national Novartis. The analysis examines the project's success factors and its risks. The reputation of researchers, the development of mutual trust among the partners, and the importance of credible commitments made at project initiation are three key factors contributing to the success of commercially focused R&D collaborations.*

Keywords: R&D, collaboration, trust, risk, credible commitments, commercialization.

Introduction

The incidence of cross-sector collaboration to conduct research is on the increase, as public sector organizations (particularly universities) seek extra revenue and companies pursue cost-effective ways of performing R&D. This paper focuses on a specific form of cross-sector collaboration in Australia, namely the government-sponsored Cooperative Research Centre (CRC) Program.[1] We explore the management of risk in cross-sector R&D collaboration through a case study from one of the most successful CRCs in Australia. We examine risk at the project level, a focus that to date has been largely lacking in the literature on interorganizational collaboration (IOC). Research on risk in collaborative arrangements is still a developing area[2] and has hardly been touched upon in studies of cross-sector collaboration.[3]

The paper begins with the case study, the *'See3' Contact Lens Project* (hereafter referred to as the 'See3' Project), which is widely considered to be an exemplar of successful R&D commercialization in a high stake and risk technology. We then draw on recent contributions to the IOC literature to explore relational risks in cross-sector collaborations, such as that of the case study, and the role trust and 'credible commitments'[4] play in managing these risks. We conclude by discussing

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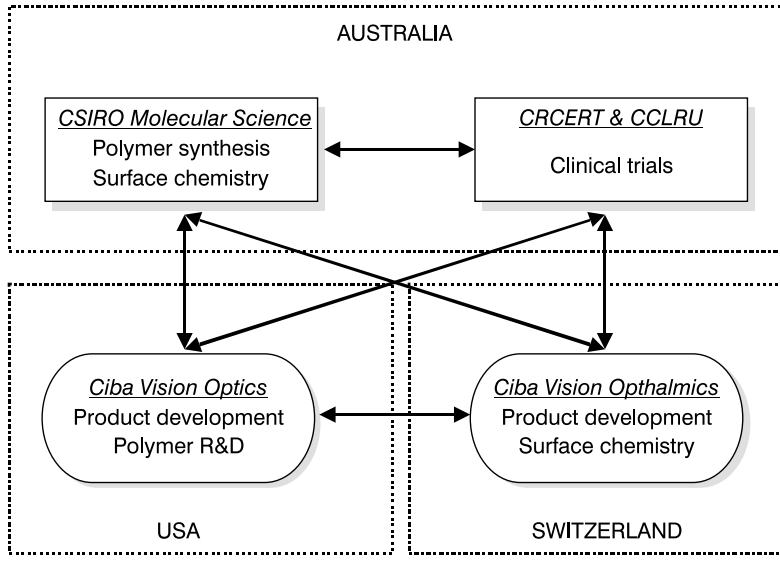

Figure 1. The collaborating partners in the See3 Project.

how risk and risk-taking are integral to understanding cross-sector collaborations and identify some critical factors in successful R&D commercialization.

The 'See3' Contact Lens Project

Three organizations—the CRC for Eye Research and Technology (CRCERT), Australia's major national public sector research agency (CSIRO), and the company Ciba Vision (CV), which is a division of the Swiss-based multi-national corporation Novartis AG—were the partners in the 'See3' Project. The project involved collaboration among scientists, engineers, clinicians and other product development specialists based in four different locations in three countries (see Figure 1). It was formally initiated in 1992, and the challenge was to create 30-day continuous wear lenses that would '. . . fulfil the desire of patients for immediate comfort, convenience and excellent vision'.[5]

The Project Partners

The CRC played a central role in this project. CRCERT had been established as one of 15 successful applicants in the first round of funding under the CRC Program. As with other CRCs, CRCERT is a consortium with units from three universities, a CSIRO division, and two other non-profit research institutes, as depicted in Figure 2. It is one of the largest CRCs in terms of total annual funding and full-time equivalent research staff.[6] It differs from most other CRCs in that it has no partners from the business sector (a result of the derivative nature of the eye care products industry in Australia, which is mostly sales focused with few companies involved in manufacture or R&D), but like all the CRCs in the medical science and technology sector, its core participants include other medical research institutes. The central participant in CRCERT is the Cornea and Contact Lens Research Unit (CCLRU) located in the School of Optometry at the University of New South Wales. The

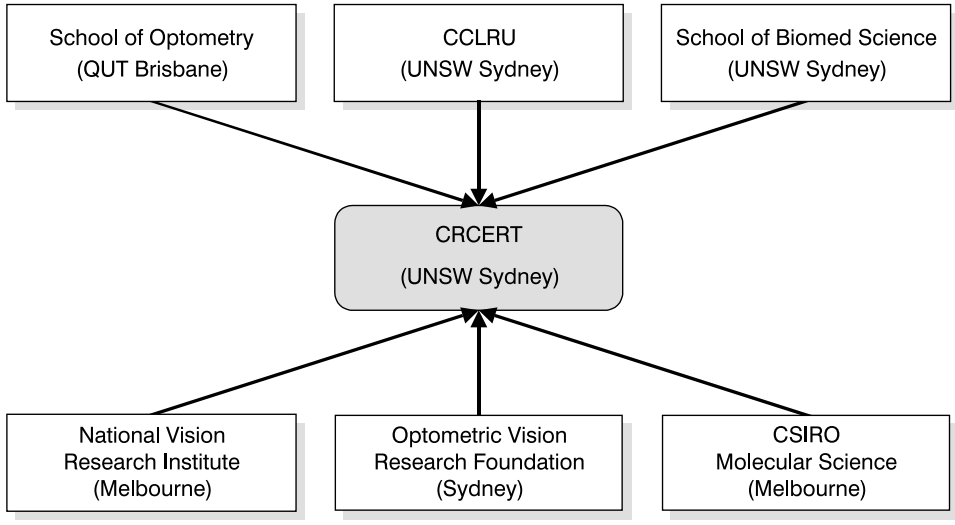

Figure 2. Core participants in the CRC for Eye Research and Technology (CRCERT).

CCLRU has developed an international reputation for contact lens research, most notably in the field of clinical evaluation. Indeed, the CCLRU has claimed that it is the largest centre in the world devoted to cornea and contact lens research. The CRC and the CCLRU have extensive linkages with other research, education and industry organizations in the eye care field, and their staff play key roles in the associated international professional and research organizations (e.g. the International Society for Contact Lens Research).

CSIRO is a statutory agency of the Commonwealth Government. It is Australia's largest R&D organization with over 6,300 employees based at 60 locations throughout the country,[7] and it receives around 13% of the Australian Government's financial support for science and innovation (nearly 50% of Government funding for the major Commonwealth research agencies).[8] In 2000/01, it received funding of $612.5 million from the Government, and also earned a further $267 million (28% of its total revenue that financial year) from the 'sale of goods and services'.[9] The particular division that collaborated on the 'See3' Project was the Melbourne-based Division of Chemicals and Polymers (since 1996 it has been part of a larger Division of Molecular Science). The main focus of this division is to contribute to the development of industries in the Chemicals and Plastics sector (47% of the division's research effort is devoted to this) and the Pharmaceutical and Human Health sector (43%). As a division, following CSIRO policy and directions, it has expressed a particular interest in collaborating with external partners to produce commercializable outcomes.

Ciba Vision (CV) was established in 1980 as a result of diversification by the US Pharmaceutical Division of the Swiss multi-national Ciba Geigy. In 1996, Ciba Geigy merged with another Swiss multi-national, Sandoz, to form Novartis AG with its core business in healthcare, agribusiness, and nutritional products. On receiving formal approval of the merger in December 1996, CV became the eye care unit of Novartis. At the time of the case study, CV had two main strategic business units: Ciba Vision Optics, responsible for contact lens and lens care products and based

in Atlanta, GA, USA (also the worldwide headquarters for CV), and Ciba Vision Opthalmics, responsible for the development and production of ophthalmic pharmaceuticals based in Bülach, Switzerland. CV was the 27th entrant in the world contact lens market, and currently it is the world's second largest contact lens company with global sales of US$1.1 billion in 2002.[10] CV's rise to industry prominence has been the result of extensive product innovation (e.g. over the period 1981–94 it introduced seven new breakthrough contact lenses and lens care products). It has also expanded through strategic acquisition, e.g. in 2000 it acquired the US contact lens manufacturer Wesley Jessen (an important player in the US industry) to become the second largest company in the industry worldwide. Although CV publicizes its approach of achieving 'innovation through partnerships',[11] the 'See3' Project was the first major international cross-sector collaboration entered into by the company.

Project Background

The contact lens industry has grown enormously since the mid-twentieth century and is now dominated by large multi-national companies such as CV, Johnson and Johnson, and Bausch and Lomb.[12] Although the first practical contact lenses (made of glass and covering the whole eye) were invented in the late-nineteenth century, it was not until 1948 that a hard plastic lens (made from poly [methyl methacrylate], or PMMA) covering only the cornea was introduced. These lenses could be worn comfortably for 6–10 hours and provided the desired visual correction after an adaptation period. But the contact lens industry did not really flourish until the 1970s following the introduction by Bausch and Lomb of soft 'hydrogel' lenses (made from poly [hydroxyethyl methacrylate] or HEMA) that could be used for daily wear. Soft lenses are very comfortable and require minimal adaptation, a significant advantage over the hard PMMA lenses. It has been estimated that nearly 90% of all contact lens wearers now use soft lenses.[13] However, despite their popularity and advantages, soft lenses do have a number of significant problems including: they are prone to the build up of deposits which can create discomfort with extended wear, they are harder to keep clean, they are more difficult to handle, and they have poor durability.

The success of the hydrogel lenses led to a search for new materials for an 'extended wear' contact lens which could be worn continuously for many days thereby making their use simpler and more convenient. But the development of a suitable material has been no trivial task because the extended wear lens has to satisfy stringent design requirements, such as: optical transparency, chemical and thermal stability, biocompatibility and wettable to tears, appropriate mechanical properties (e.g. sufficient durability and strength), suitability for mass production and—most importantly—high oxygen permeability.[14] For soft lenses, two main approaches were initially pursued from the 1980s: the introduction of very thin HEMA lenses with higher oxygen permeability (e.g. Ciba-Geigy's 'Cibathin' and Bausch and Lomb's 'Soflens O Series'), and high water content hydrogel lenses (e.g. Johnson and Johnson's 'Accuvue'). After the introduction of the first hydrogel lenses designed for extended wear in the mid-1980s, many wearers began wearing them for periods of one to three months.[15] But this usage mode led to an increased risk of corneal ulcers[16] and the first generation of extended wear contact lenses fell into disfavour with eyecare practitioners.[17]

Given that modified hydrogel lenses had proven to be unsuitable, a search commenced for new materials and researchers began to focus on combining hydrogels with silicone-containing polymers that offered the benefit of high oxygen permeability. The major problem faced in the development of these new materials was that of achieving an optimum surface chemistry with high biocompatibility and good wetting characteristics. In the early 1990s all of the major companies were pursuing this approach (as a regulatory specialist at CV later noted: 'The early '90s marked the beginnings of a strong commitment and targeted initiatives by industry to develop 30-night continuous wear [lenses] as a safe and effective vision-correction option'[18]), but by the mid-1990s no silicone hydrogel contact lenses were yet commercially available for extended wear.

The 'See3' Project and its Outcomes

The origins of the project to develop the extended wear lens are interesting and underline the importance of reputation in the initiation of cross-sector collaborative ventures.[19] Prior to the project, CV was generally aware of the CCLRU's clinical work and of its director Professor Brien Holden, a leading researcher in the field who had published a seminal study that established the level of oxygen permeability required of a contact lens to avoid oedema in overnight wear.[20] But this awareness was not sufficient. In the early-1990s, the Head of CV's R&D and Marketing activities began reorganizing the company's research effort by reducing the number of projects and focusing on a select few. At around the same time, two people who knew of the fledgling CRC (an ex-employee of the CCLRU and another acquaintance) suggested to the CV executive that this was a group which had much to offer the company. As a result, the CV executive met with the CRC's Director and an R&D collaboration contract was negotiated. This seven-year contract was signed in January 1993. Under this contract, the company agreed to provide substantial funding for the R&D project (initially a sum of 5 million Swiss francs over three years was committed) and this was to be matched by the CRC with equivalent resources, largely in-kind contributions of CRC researcher time. The 'See3' Project was set up under the CRC's Biomaterials Program, and different participants in the Centre were assigned tasks according to their areas of expertise; e.g. CSIRO was responsible for surface science work (to create special lens coatings to hold a tear film and resist fouling) and polymer synthesis, while the CCLRU assumed responsibility for the clinical trials of the developed products. Parallel R&D and product development work was also carried out within two units of CV, one in the USA and the other in Switzerland.

The R&D project was substantial, involving around 100 people working in teams at four sites. The key tasks of the project were: to develop a contact lens which could be worn continuously for up to 30 days; to manage the IP created by the project; to test the effectiveness and safety of the new lens in non-clinical and clinical trials; to obtain regulatory approval for the final product; and to develop a commercially viable manufacturing process. The project proceeded as planned and a new surface-treated material, described by the company as 'an entirely new revolutionary material' and '. . . the most significant breakthrough in contact lens material since the introduction of HEMA 25 years ago'[21] named 'lotrafilcon A' was invented.[22] Patent applications for the new extended wear lenses were first filed in Germany, Switzerland and the USA in 1995. The development process also involved extensive non-clinical testing to provide 'reasonable assurance of the safety' of the

new lens prior to clinical trials. This testing, mainly conducted in the laboratory and using animals as test subjects, involved studies of biocompatibility, physiochemical properties, compatibility with eye-care systems, sterility and stability. On completion of the non-clinical tests, controlled clinical studies were initiated in a number of countries. FDA clearance (under the pre-market approval provisions of medical device regulation in that country) for the daily wear of the lenses was obtained in 1997, but at this stage they were not marketed in the USA.

CV publicly announced the 'breakthrough high-oxygen soft contact lens material' in November 1998 and indicated that the lenses, branded as 'Focus Night and Day', were to be test marketed in Mexico for continuous wear of up to six nights.[23] In January 1999, the new product was launched in Spain with a limited release in Australia and New Zealand later that year. The President of CV's Lens Business Unit described the launch strategy as follows: 'Recognizing that practitioner confidence in the lens must be earned, we are launching the lens for six-night wear initially in order to give practitioners a chance to experience the lens and judge its performance on their own. . . . As practitioners fit and evaluate the lens on a six-night wear basis, we will continue to build on the base of clinical support . . . for up to 30-night extended wear'.[24] A major milestone was achieved in April 1999 when Focus Night and Day lenses were given 'CE Mark' approval by the European Union thereby enabling the company to market the product as safe for 30-night extended wear throughout Europe.[25]

The next major hurdle, to open up the important and lucrative US market, was to obtain FDA approval. A pre-market application was filed with the FDA in March 2001 and that application was amended many times during 2001. To support the company's claim for product safety and effectiveness, there was a one year controlled clinical trial involving 59 investigative sites throughout the USA and 1,395 subjects (a trial claimed by the head of CV's continuous wear research programs to be '. . . one of the largest prospective contact lens studies conducted to date in support of safety and effectiveness'[26]). The results of this trial were presented to a hearing of the FDA's Opthalmic Devices Panel in July 2001 where the application for FDA approval was reviewed. By this stage, it was estimated that there were around 250,000 wearers of the lens in over 40 countries with about 175,000 patient years of accumulated experience as well as the results of clinical trials in a number of countries.[27] In October 2001, the FDA formally approved the sale of Focus Night and Day contact lenses in the USA for daily or extended wear of up to 30 nights continuously but subject to a number of conditions (e.g. approved labelling, advertising restrictions, a one year follow-up study and a requirement to report any adverse reactions or defective devices). Shortly afterwards in November 2001, CV's main competitor Bausch and Lomb were given FDA approval for a rival 30-day extended wear product, 'Purevision', made from another patented silicone hydrogel 'balafilcon A' with a higher water content (36%) and a different surface treatment. The Purevision lens had been the first silicone hydrogel lens offered for sale in the USA, and had been available there for up to seven days of continuous wear following FDA approval for this less extensive usage in February 1999.

Assessing the Project Process

This was a large and ambitious project, but one which all of the participants agreed was highly successful. It was a high stakes project with a potentially high commercial

pay-off.[28] However, like any R&D project it did have significant risks for the collaborating partners, both collectively and individually, some that affect all forms of R&D collaboration and others that are specific to cross-sector collaboration. Briefly, there were four main sources of risk for the project itself and hence to the partners collectively. Firstly, there are the widely recognized risks associated with the uncertainties of R&D itself. That is, at the outset of an R&D programme or project the outcomes can never be predicted with any certainty; for example, the surface chemistry research for the 'See3' Project may not have produced, in the time available, the required knowledge to develop a viable coating process for the new lens. Secondly, for a health-care product that falls within the purview of regulatory regimes, the process of meeting the requirements of government regulation raises many risks and extends the timeframe between invention and market introduction (it is noteworthy that there were more than six years between the patenting of the new lenses and the approval for their extended wear by the FDA). Pre-clinical and clinical trials can reveal unexpected problems, and the requirements of regulatory bodies can impose stringent conditions on the developers of new health-care products. Thirdly, new product development is rarely conducted in a vacuum and competition is also a source of risk, e.g. competitors can out-innovate and either pre-empt the launch of a new product or render it obsolete. In the case of extended wear lenses, competition also comes from alternative products such as disposable contact lenses and laser surgery to correct vision impairments. Fourthly, the management of IP entails many risks. The nature of this type of risk, and the costs involved in pursuing an aggressive IP protection strategy, was illustrated by the patent infringement litigation commenced by CV against Bausch and Lomb initially in 1999.[29]

But not only were there risks common to all partners in the project, each of the partners faced different types of risk. For CSIRO, as a public sector research agency committed to enhancing the economic advantage of Australia, there were risks in forming a close relationship with a Swiss multi-national corporation, including technology leakage, a dilution of the Australian-focused research effort, and a transfer of IP that could result in competitive disadvantage to Australian companies. For the CRC, there was a risk that a failed project (for whatever reason) would damage the Centre's international reputation or that by collaborating with one particular company its independence would be compromised. For the company, the risks were of a commercial nature, e.g. that the investment did not provide a return, that the technological development was pre-empted by a competitor and that the market for extended wear lenses did not materialize. The relational risks associated with opportunism were high for the company and the choice of a university partner was strategically significant in attenuating these risks. Given that the CRC was a key research organization in the global context, with already valuable intellectual capital, securing this partnership also meant that competitors were excluded.

Despite risks such as these, the project started with three highly motivated organizations. Each had more to gain than it could lose from the collaboration: CV to be first to market and so capture 'first-mover' advantages in a highly competitive industry; CSIRO to gain external revenue, to demonstrate its relevance and to reinforce its international reputation in specific areas of scientific research; the CRC to gain external revenue for its R&D programmes and to build on the reputation of the CCLRU in establishing itself as *'the leading world institution for cornea and contact lens research'*.[30] The CRC, whose non-commercial partners were

embedded (and indeed were central actors) in international scientific and clinical networks, provided a suitable vehicle for the establishment of the collaboration. Through the CRC, the company could gain access to a diverse range of expertise and resources organized under a single umbrella. The reputations of key personnel in the CRC (e.g. its Director) and the CSIRO (e.g. individual scientists working in the field of polymer synthesis) were central to their employing organizations' desirability as collaborative partners.

According to research team leaders, the success of the project was largely due to three main factors: the initial commitments made by the partners, the task organization and the project management approach adopted. Before it formally commenced, all participants were required to make explicit commitments to the project. These included: the allocation of resources in accordance with the role and stake of each of the parties,[31] the free sharing of project information with an explicit commitment to have no secrets or hidden agendas, and the joint assignation of IP rights resulting from the project. This latter commitment ensured that, for the CRC and CSIRO, there would be a flow of royalties if the project was successful thus providing a material return for their participation. Through these commitments, trust developed between the CRC and its private sector partner, as discussed below, a result evidenced by the company's continued collaborative relationship with the CRC.

A central element of the project's overall organization was that 'critical tasks' (such as polymer synthesis, surface chemistry and clinical assessment) were placed on 'parallel tracks', i.e. were conducted at several sites simultaneously. This was important in terms of balancing the power relationships in the project by not allowing any one group to become too central to the process. Phased commitments ensured that knowledge was shared as the project unfolded. It also created healthy rivalry. For example, the polymer synthesis laboratory work was carried out concurrently at CSIRO, CV USA and CV Switzerland; the three teams had the same goals, but used differing and complementary approaches. This lead to 'friendly competition', with the teams benchmarking each other, and ensured that the project was rarely brought to a halt because of technical problems at one site. Also, with different teams working in parallel on the same problem, more options could be explored and tested in the time available.

From a project management perspective, there was considerable emphasis placed on fostering communication and on team building among the participants. This was seen as crucial, given the different communication styles of the collaborators (e.g. polymer chemists and clinical ophthalmologists) and the differences in their work environments (most notably between the laboratory-based work of the scientists and the more structured activities of other specialists such as product development engineers). Three media were provided to facilitate high levels of communication and support collaboration among all participants. The most critical of these was the provision of a secure computer network linking all members of the project teams and the relevant organizational managers. Access to project information was via a groupware workspace through which participants could: email each other, communicate in a synchronous 'chat' mode, gain access to project databases and documentation,[32] contribute to 'bulletin board' discussion groups, securely transfer files, and obtain regular project updates. The philosophy behind this 'groupware-based' network was that all participants, across both disciplines and organizations, could access virtually all project information to support team integration and contribute to 'project energy'. Project information

could be accessed and communication carried out (either synchronously or asynchronously) at any time through this network, and this feature was considered to be more consonant with the working style of laboratory scientists. This mode of communication was augmented with regular teleconferences among the different teams, held every one or two weeks. A third medium, based on an explicit recognition of the limitations of electronically mediated communication, was a series of six-monthly face-to-face project review meetings, held over a three to four day period at what were seen by the public sector researchers as 'prestige locations'.

Risk, Trust and Credible Commitments

Previous studies have emphasized the importance of mutual trust for the success of IOCs in which relational continuity is important, such as in R&D projects.[33] As Macdonald *et al.* have put it:[34]

> (Trust) is required to compensate for the deficiency inherent in formal agreements—basically that, no matter how carefully they are compiled, they cannot cover every eventuality. So, an unwritten agreement accompanies every collaboration, by which all parties understand what else is required of them beyond the formal terms of collaboration. While a collaboration may be established instantly, the trust, which underlies the success of the collaboration, cannot.

Two inter-related constructs have been invoked in studies of IOC to explain relational continuity, trust and risk. As noted above, risks[35] arise from many sources in collaborative ventures, but for the individual partners both relationships of dependence and the possibility of opportunistic behaviour (i.e. one partner in pursuing its own self-interest acts opportunistically to the detriment of the other partners) are a source of particular concern. The concept of trust[36] has had a long history in collaboration studies and is seen as a major contributor to risk taking. Where two or more parties trust each other, they are usually more prepared to expose themselves to greater risks by making themselves vulnerable to others. Trusting others carries the risk that such trust may be misplaced and, for some, trust always carries the possibility of the risk of betrayal.[37] It is commonly accepted that in R&D partnerships, trust encourages risk taking as well as the sharing of proprietary information, and also mitigates the need for excessive controls in what is largely an unpredictable and uncertain area. Further, trust reduces the transaction costs associated with contracting and legal solutions to the formation of partnerships. Trusting behaviour (which entails expectations of positive outcomes[38]) is built on two forms of trust, and each of these is central to the management of relational risk.

First there is a resilient form of trust—often termed 'goodwill trust'—associated with having personal qualities that can be relied on, such as being equitable, being fair in dealings, having high integrity and standards of conduct, reciprocating favours, being able to keep confidences, and being selfless.[39] Such a form of trust develops over time through repeated successful encounters and, if sufficiently strong, can lead to 'hand-shake' agreements. In cross-sector collaborations, goodwill trust already exists for academics and other public sector researchers who have a public reputation as having the virtues associated with

goodwill trust. It has also been suggested that 'third parties' (i.e. those standing outside the commercial world), such as universities, can become 'trustees for agreements' or act as a '*custos collaborationis*' for competitors and be entrusted to protect IP.[40] Evidence of public sector partners playing such a role has been found, for example, in a study of cross-sector collaboration in the German automobile industry where a research institute acted as a custodian of IP and as an intermediary between small supplier firms and a large manufacturer.[41] In theorizing why federal laboratories are invited to participate in R&D more often in joint ventures where there are large numbers of partners, Leyden and Link contend that the public sector agencies can reduce the partner firms' monitoring and transaction costs in the venture by, *inter alia*, acting in the role of 'honest broker'.[42] Such a role was exemplified in an Italian case study, where the public sector agencies played a role in discouraging opportunistic behaviour by private sector partners in R&D joint ventures.[43]

Private sector partners have recognized that the relational risks in cross-sector collaborations have been relatively small in probability and impact. The relational risk of opportunism is much less of a problem when partners are not market driven and the relationships are complementary, as in the case of the 'See3' Project. Given their historical lack of a profit focus, as well as their missions and modes of operation, public sector organizations are far less likely to engage in calculated strategies and opportunistic behaviour, such as free-riding, capturing a disproportionate share of the benefits, or appropriating and exploiting proprietary knowledge of other partners. The reputation value of public sector researchers affords the private sector a very cheap and effective way of reducing the expensive transaction costs of managing distrust in high risk ventures while not having to pay market prices for the cross-sector knowledge generating process.[44]

Second, a more fragile form of trust—often referred to as 'competence trust'—is associated with expertise, know-how, and the ability and capacity to perform tasks, as distinct from the intention of performance. Again, repeated interactions between partners build this form of trust. However, in some circumstances, the reputation of a partner can be a catalyst for entering into a collaboration even though the partners might not be personally known to each other. In this event, reputation can be the basis for forming a partnership, as happened in the 'See3' Project, but it is not a substitute for competence-based trust because there is always the chance that a partner might not live up to the reputation. The reputation of public sector researchers, especially internationally renowned ones such as those associated with the 'See3' Project, pre-dated the collaboration. The collaboration could have either enhanced or damaged the reputation of the researchers depending on how the project turned out. Equally though, the researchers could have failed to deliver on critical phases of the project thus destroying the basis of competence trust with the other partners and ultimately their research reputations. That is why partners in R&D collaborations seek out proxies of trust, in the form of credible commitments, to ensure that the collaboration works and risks are managed.[45]

Fear of opportunism, particularly partners appropriating proprietary knowledge, outlearning other partners, and leaking or swapping information with competitors, create 'boomerang hazards' in many R&D collaborative ventures.[46] The fear of opportunism creates the need to obtain certain forms of commitment to ensure relational risks are managed while trust is still developing. Relational risks can be seen as 'vulnerability costs' that organizations need to prepare for as '. . . a

premium for the risk involved in joining the collaboration'.[47] These costs derive from two main sources: (a) structural dependence and (b) information asymmetry. Structural dependence occurs, for example, when an external research partner is used for a long period of time and becomes a substitute for in-house capability. Information asymmetry occurs when one of the partners has less information about the collaborative venture than the other(s) and hence faces the possibility of exploitation as a result. This 'information dominance' creates an unbalanced relationship of dependence leading to the possibility that the more vulnerable partner becomes the victim of opportunistic behaviour. So, a key question here is: how are such risks managed in cross-sector collaborations, as exemplified by the case study?

In terms of structural dependence, none of the partners restricted their research to the 'See3' Project, with the CRC and CSIRO continuing to work with other companies. CV did not stop its in-house research as a result of the collaboration, but rather used the project to focus its in-house efforts. This was a project in which the partners were complementary to each other, meaning none could have achieved the desired outcome without the support of the others. The partners established common goals at an early stage and this affected how the project was negotiated. Moreover, the CRC was instrumental in initiating the collaboration and was not in the traditional role of many researchers when dealing with large companies. Large companies often see their relationship with public sector partners in terms of 'information gifts', whereby the latter must offer something interesting in order to attract a commercial commitment. This has been described as a 'commercial courtship ritual', necessary to get industry involved.[48] Once they are engaged in an R&D collaboration, large companies usually demand significant control over the resulting IP. In R&D projects, information asymmetry is hard to manage in ways that are beneficial to all partners, and much harder if structural dependence favours one partner considerably more over the others.

Contracts and other formalized agreements are usually used to prevent proprietary knowledge being exploited. In the 'See3' Project, this was achieved through the joint assignation of IP which meant that all partners were potentially able to derive monetary benefits on a pro rata basis. But formal arrangements in R&D partnerships often create fragile forms of trust and can carry onerous costs of enforcement. In contrast, 'credible commitments', which can be of a contractual or non-contractual nature, can be more successfully deployed to facilitate the sharing of proprietary knowledge thereby reducing risks of opportunism. These commitments can be used either on their own or in conjunction with contracts, and in the 'See3' Project were deployed in creative and comprehensive ways to facilitate both the sharing and protection of IP. This creativity had much to do with the centrality of the project to the core business or activity of all partners and to protecting the competitive advantage of all concerned.[49]

One form of credible commitment is the establishment of protocols for information sharing, and this was clearly evident in the 'See3' Project; e.g. in the philosophy of 'over dissemination' that was built around a secure network, in the groupware-based technology giving information access to all participants, and in the general agreement to share information as openly as possible. Other forms of credible commitment include, for example, the development of systematic approaches, which in the 'See3' Project involved teams working at separate sites on different tasks, and phased commitments, which in the 'See3' Project entailed ensuring that knowledge was shared among the teams as the project unfolded.

Higher level commitments (i.e. those involving more tangible and costly undertakings) include joint equity in projects, the sharing of royalties, advanced investments from larger partners made before a project commences, the larger partner contributing a higher proportion of funds, and specific upfront commitments to the project—nearly all of which occurred in the 'See3' Project.

Credible commitments, or acts of 'pledging', can lead to spiralling trust based on 'self-amplifying reciprocity',[50] which arises as partners build a track record of successful execution of commitments. This usually leads to further collaboration, as resulted from the 'See3' Project after which CV continued to work with the CRC. Reciprocity is important in building trust and this entails balancing the power relationships between collaborating partners. Furthermore, credible commitments influence the social capital or the quality of collaborative linkages.[51] More importantly, credible commitments are not only 'proxies of trust', they also act as forms of 'enforceable trust' by setting the norms of compliance as well as the sanctions for breaches of agreed commitments.

It is generally acknowledged that cross-sector collaborations are double-edged swords for all partners, and for public sector researchers the single biggest problem is that their reputations can become a commodity when traded for research dollars.[52] While the main benefit of R&D collaboration for public sector organizations is access to extra funding, it does expose them to a range of risks that have not been widely discussed in studies of IOC, most notably the potential for damage to academic reputations. Cross-sector collaborations, especially if commercialization is the objective, can significantly alter the trust dynamics that underpin research and innovation in an academic community. The term 'intermediated trust' has been used to describe the social basis of relationships within research communities, to which reputation and academic credentialism are fundamental.[53] As the social capital of scientific credibility, intermediated trust is considered to be different to the other forms of trust discussed so far. Scientific communities develop their knowledge bases, and the associated potential to innovate, from both formal and informal networking which involves, through gossip and chatting among researchers, the sharing of privileged and proprietary knowledge, as well as the exchange of crucial and unpublished information on research (including current thinking on pressing problems and the foreshadowing of future areas of research).[54] Confidentiality agreements, the commodification of knowledge in the form of IP and other constraints imposed due to commercialization can undermine scientific credibility because of the secrecy and exclusivity surrounding the research findings, as is particularly the case with project agreements which restrict publication. Studies in the US and Australia have confirmed this trend.[55]

Conclusions

Given that our research has focused on the level of R&D projects, the case study does lend support to the notion that credible commitments are important in explaining successful cross-sector collaboration where commercialization and high-risk projects are involved. What was remarkable about the 'See3' Project was the way in which all forms of commitment were deployed. None on their own was sufficient to ensure that relational risks were managed, but we hypothesize that the higher the number of credible commitments made by the partners in a collaboration the more likely it is to succeed. We further hypothesize that these commitments will help resolve the issues of structural dependence and information asymmetry to ensure that relationships of

trust do emerge. The 'See3' Project suggests that developing a typology of credible commitments, across a range of project types, and linking this to the study of risk will be invaluable in the growing area of research on R&D collaboration. We believe that the suite of credible commitments evident in this project are not common and we want to find out which combinations work better than others. There is a need for more studies of cross-sector collaborations that comprise multiple projects, with differing levels of success and partners which can be competitors or complementary or both, to fully appreciate how risks are managed and to determine whether credible commitments remain a robust explanation of the success of cross-sector R&D collaborations. The commercialization and the commodification of knowledge in cross-sector collaborations not only introduces new forms of commitment, they also put pressure on the reputations of public sector researchers. We have argued that credible commitments are likely to become the basis upon which relational risks are managed and trust relations transformed in cross-sector collaborations driven by the commercialization imperative.

In the 'See3' Project, each partner's risks were different but, in the context of their own domains, the risks were high and the benefits of commercialization could only occur simultaneously for all partners. One of the interesting findings of this case study was that cross-sector collaborations could damage the reputations of all involved, if the risks are sufficiently high. Reputation has to be differentiated among public sector researchers. In the case study, the CRC Director already had an established reputation and the issue for him was at the very least not to damage this, as opposed to the problems involved in establishing it. We have yet to fully explore how the reputations of researchers are enhanced or impeded by cross-sector collaborations. Our case study also departs from a number of others that have been published in that it was a public sector agency, the CRC, that sought private sector collaboration and initiated the project. This facet of the 'See3' Project supports other studies which have concluded that it is misleading to treat public sector researchers as an homogeneous group,[56] and it undermines the belief that the private sector drives the commercialization agenda. However, it also true that without the 'barter economy of science',[57] knowledge about the CRC, and particularly the work of eminent scientists such as Brien Holden, would not have been in the public domain. Yet the 'See3' Project comprised a community of scientists who already had established international reputations and whose research needed a commercial partner to succeed. While researcher reputation was a major factor for CV in entering into the collaboration, the added attraction of having all the critical external IP needed for the project residing in one research entity (namely the CRC) made the partnership less risky for all concerned. For the researchers, the critical mass of knowledge and expertise within the CRC mitigated the relationship of structural dependency between the public sector organizations (i.e. the CSIRO and the universities involved with the project) and a large and wealthy multi-national corporation.

While we have focused our discussion on trust and risk, our case analysis has also revealed that communication and team building were also critical factors in the success of the 'See3' Project. Also, although we have not elaborated on it in the case study, the quality of leadership in such collaborations and the role of product champions requires further examination. We would finally add that other areas of risk management in R&D projects also need to be investigated to give a more complete account of why some cross-sector collaborations fail while others succeed.

Notes and References

1. The CRC Program was launched by the Australian Government in May 1990 in order to encourage cooperation amongst public sector researchers (e.g. in universities) and the private sector users of research knowledge. Each CRC, which is a research consortium with partners from industry, public sector research agencies and universities, is established under a formal contract to the Government and is funded for an initial period of seven years. A CRC's government funds are supplemented by resources committed by the partners, including both financial and 'in-kind' contributions.
2. See, for example: Bart Nooteboom, *Inter-Firm Alliances—Analysis and Design*, Routledge, London, 1999, pp. 109–47; T. K. Das and B.-S. Teng, 'Managing risks in strategic alliances', *Academy of Management Executive*, 13, 4, 1999, pp. 1–13; T. K. Das and B.-S. Teng, 'Trust, control and risk in strategic alliances: an integrated framework', *Organization Studies*, 22, 2, 2001, pp. 251–83.
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19. The case study data was obtained from a wide range of secondary sources in the public domain (e.g. the CRC's Annual Reports and the Ciba Vision website), as well as from interviews with key project team leaders in Australia.
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29. In a first action, CV claimed that Bausch and Lomb's Purevision extended wear lens infringed the Nicolson Patents. Bausch and Lomb retaliated by seeking to invalidate the Nicolson patents through re-examination proceedings. This action failed, and the US Patents and Trademarks Office reaffirmed the validity of CV's patents. In a later action (May 2001), CV claimed that the Purevision lens infringed the 'Harvey patent' for silicone hydrogels (a patent assigned in April 1985 to Sola USA Inc which became part of Wesley Jessen, a company which in turn was acquired by CV). After much litigation (and counter-action) the resulting judgements in various US courts, affirming there had been a breach of CV's patents, have stopped the production and sale of the Purevision lens in the US.
30. Cornea and Contact Lens Research Unit (CCLRU) website, http://www.unsw.edu.au/clients/crcert/CCLRU01.HTM, accessed 1 May 2000.
31. Resources allocated by the public sector agencies to the project meant committed facilities and the dedicated time of researchers, while for the company it also included an advanced commitment of capital (5 million Swiss francs) in the expectation of a return on the investment.
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was important evidence to be used in patent applications and in defending against any subsequent challenges to the validity of the patents obtained.

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