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Achieving Effective Cross-Sector R&D Collaboration: A Proposed Management Framework

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ABSTRACT *Cross-sector R&D collaboration, as exemplified by the Australian Cooperative Research Centre Program, is increasing in incidence due to government policies and corporate practices. While the benefits of such collaborations are widely promoted, the resulting relationships (typically involving companies, universities and public sector research agencies) can be difficult to manage so as to achieve beneficial outcomes for all partners. A management framework for establishing these collaborations is proposed. This framework is based on four tensions in cross-sector collaborations, and it takes the perspective that knowledge created for mutual benefit is the common focus of these ventures.*

Keywords: R&D; collaboration; Cooperative Research Centres; management; knowledge; commercialisation.

Introduction

This is a practically-oriented paper which focuses on the establishment and management of a particular form of interorganisational collaboration in a specific context: cross-sector R&D collaboration in Australia under the Cooperative Research Centres (CRC) Program. While the paper is aimed at this specific Program, the approach could be generalisable to other forms of cross-sector collaboration in other contexts. As such, it deals with the practical consequences of a major current trend in science and technology policy, i.e. the encouragement of cross-sector linkages and the transfer of potentially-valuable knowledge from the public to private sectors.[1] The paper proposes a management framework designed to help R&D managers in both public and private sectors to design effective collaborative ventures. The management framework and its continuing development arose out of an interesting collaboration, which has often involved diverging and contrasting viewpoints. The authors of this paper have been both participants and observers of cross-sector collaborations for more than a decade, one of us from within industry and the other within academia. We have experienced projects that

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progressed well and others that did not. We have also observed a divergence of opinion among the partners about the outcomes of a collaborative project. Having diverse and often conflicting views may be both a strength and a weakness, and in this paper we explore what lies behind some of the differences in views and values commonly held in industry and in academia.

We develop the paper in the following way. Firstly we provide a background by discussing the growing importance of cross-sector R&D collaboration in Australia and by reviewing responses in the academic literature to the problematic nature of this form of collaboration. We then present an overview of our management framework, clarifying its key elements. Finally we conclude by discussing the current status of this approach.

Cross-Sector R&D Collaboration in Australia

It is now widely recognised that there has been a growing incidence in collaboration among organisations to perform R&D.[2] An increasingly important area of this interorganisational collaboration, which is driven both by government policies and by corporate strategies, has been that of cross-sector R&D collaboration.[3] This involves universities, companies, and public sector research agencies collaborating on R&D projects either directly (e.g. in partnerships, consortia or joint ventures) or under the auspices of intermediary agencies such as technology councils and extension services, commercialisation agencies, industry associations, collaborative research centres, and various forms of business and technology 'incubators'. It is through these collaborative arrangements that technology and other potentially-valuable forms of knowledge are transferred from public to private sectors, within and across national innovation systems.[4]

The issue of cross-sector R&D collaboration has been a recurrent theme in science and technology policy debates in Australia since at least the late-1980s and has been given greater prominence more recently.[5] A widely-held perspective has been that Australia's national system of innovation has structural weaknesses and that '… the flow of technology and information among people, enterprises and institutions' which is central to innovation is not well developed.[6] One policy response to address this deficiency in the flow of potentially-useful knowledge from its sources in research performing organisations to its application in industry has been that of the Cooperative Research Centres (CRC) Program. This Program was established by the Australian Government in 1990 specifically to encourage cooperation amongst researchers, mainly located in universities and public sector research agencies (in the latter case most notably Australia's major public sector research agency CSIRO) and research users mainly located in the private sector. It was hoped that this would strengthen the links between research and its practical application, or as the Minister of Science put it at the launch of the Program in March 1991: 'Australia must match the technology push provided by its strong research base with the demand pull of industry and other research users'. More recently, the focus of the Program on commercialisation, 'especially through the development of novel technologies which can assist industries become more innovative, competitive and productive',[7] has been reinforced.

More than 150 CRCs have been created since the first 15 were announced in 1991 (there are currently 72 operating in six sectors), and from then until 2005 the Commonwealth Government had contributed $2.2 billion to the Program. Industry and the other public sector participants (i.e. principally universities, public sector

research agencies such as CSIRO, and State Governments) had contributed a further $7.4 billion in cash and in-kind resources to the Program, resulting in a total resource commitment of around $9.6 billion over 12 years[8]—a not insignificant amount in Australia's national innovation system. While this is a significant investment by both the Commonwealth Government and the public sector agencies involved, it is not the only public sector commitment in this area because universities and research agencies collaborate with industry partners in a variety of other ways, e.g. through contract research and joint ventures. The result of this trend towards greater cross-sector R&D collaboration has been that the public and private sectors are much less independent of each other with respect to knowledge production and exploitation, and they have become much more interactive and interdependent with overlapping institutional spheres.[9]

The policy goal in fostering greater cross-sector R&D collaboration is to ensure that not only is 'useable knowledge' created but that it is commercially exploited and thereby translated into economic benefits. A relationship of mutual benefit in this arrangement is also envisaged: companies can access new knowledge in cost-effective and less risky ways, and public sector research agencies gain access to non-government sources of funding as well as engagement with practical problems (thereby contributing to their 'relevance'). It was within this context that the need for a systematic framework to help organisations form successful collaborative ventures was identified. The need so identified arose from the reported negative experiences of many participants in cross-sector R&D collaborations,[10] a widely-held view among policy commentators that the CRCs and universities are not very effective in commercialising new ideas,[11] and the growing recognition that cross-sector collaborations are risky for the partners and especially so for the public sector partners, most notably universities.[12]

Addressing the Problematic Nature of R&D Collaboration

While the benefits of cross-sector R&D collaborations are widely cited, the relationships formed can be difficult to manage so that beneficial outcomes for all the partners can be achieved and any negative consequences avoided. Indeed, it has often been argued that such collaborations can be a particularly 'risky business' for the partners involved, not least because of the uncertainties associated with R&D.[13] The risks and issues involved in interorganisational collaboration generally, and R&D collaboration specifically, have been the subject of a wide range of academic studies, and there is no shortage of suggestions arising from these studies as to how the problems can be addressed. Reviewing the diverse literatures, two main approaches can be identified. The first derives from what might loosely be considered as the organisational design literature,[14] although this draws on a number of different disciplines and theoretical perspectives. In this approach Nooteboom,[15] for example, in extending a Transaction Costs Economics (TCE) perspective, proposes a framework for identifying appropriate structural forms and modes of governance for interorganisational collaboration initiatives as well as specifying collaboration design principles ('… which aims to achieve goals that are relevant to the context and to solve problems connected with goal and context'). This framework delineates a set of principles covering, among other things, the mode of governance to be adopted in a particular situation, the degree of integration that is desirable, the form of organisation and the means required to deal with such problems as spillovers whereby valuable knowledge is leaked to actual or potential competitors.

The problem with contributions from this type of approach, as seen from the perspective of an R&D manager embarking on the establishment of a new collaboration, is that they are often presented at a high level of abstraction and tend to focus on what are 'macro-issues'. Although this does provide useful insights into the sorts of problems that may be encountered by managers (e.g. the possibility of one or more partners acting opportunistically to the detriment of the other partners), and the means that can be used to deal with these problems, the approach often does not engage with the detail of managing operational or 'micro-level' issues. Furthermore, in the context discussed by this paper, CRC R&D managers do not start with a blank slate. Rather, they operate within a clearly-defined framework whereby the structure, governance mode and principles of the collaboration are specified in a formal project agreement among the partners. The issues that managers confront, therefore, are more concerned with the 'nuts and bolts' of making the collaboration 'work' within an agreement which broadly establishes goals, roles, scope and operating procedures. Although the agreement prescribes the basis of collaboration (e.g. specifying who will do what within a given timeframe and determining how the budget will be allocated), this is often not sufficient to ensure that the desired collaboration will indeed occur and that any problems arising (e.g. a partner not performing as indicated in the agreement) will be addressed to ensure that the venture 'stays on track'.

The second approach encompasses a more diverse literature which provides general advice on how cross-sector research collaborations can be made more effective.[16] A common theme expressed in this literature, reflecting the major changes that have occurred to the role and organisation of academic public science, is that there are major concerns among members of the academic community about this form of collaboration.[17] One contributor to this literature presents an industry view that 'cost-effective university collaborations meet three criteria: they align with the technology strategy of the company; they are managed on time and on budget; and the results are harvested efficiently to impact products or processes'.[18] A recent European study by a group of industry R&D managers also expressed the view that collaborative R&D must be integrated into company strategy, and that clear objectives with the right partners, good project management, and learning something from every collaboration were 'good practice' requirements.[19]

It has been suggested that being part of both scientific and commercial networks is crucial to drive innovation, and that the nature of the interface between these networks can have a strong influence on the innovation process.[20] This arises from the observation that links between the two communities are shaped by some key scientists who engage in the practices of both, but also argues 'a coherent strategy that builds connections in complementary layers to be more effective'. Further, the nature of the innovation being pursued will impact on the nature of the relationships required, with radical innovation requiring strong personal interaction to transfer the tacit knowledge of the inventor. Santoro and Betts have noted the potentially beneficial impact of an industry/university champion within an individual firm.[21] They also note that creative agreements can stimulate project participants, and that clear guidelines about IP, patent ownership and licensing agreements can clarify the expectations of the collaborating enterprise. As we discuss below, we see these recommendations in terms of two elements of a strategy for managing cross-sector

collaborations: introduce a respected intermediary and introduce clarifying practices and procedures. We have also observed a third and complementary strategy for a collaboration partner: minimise the exposure to the collaboration by minimising its scope.

Perhaps the most developed attempt to date at providing useful guidelines in this area has been that of Barnes *et al.* who have proposed a 'good practice' model for successful university/industry research collaborations.[22] This model was derived from a comparative analysis of six case studies of university–industry collaboration (unlike many other contributors to this literature, the model was based on systematic empirical research), and it identified six key areas that need to be addressed in the management of collaborative R&D projects to ensure their success. The 'good practice' key areas identified by Barnes *et al.* were: (a) partner evaluation to assess interest and commitment; (b) high quality project management personnel and practices; (c) a need to build and sustain trust, commitment and continuity among the partners; (d) flexible and environmentally-responsive management processes; (e) measures to sustain the interest and commitment of the industry partners; and (f) an emphasis on achieving mutual benefit through the collaboration so as to ensure there is an appropriate balance between academic objectives and industrial priorities.

However, while this model, and the prescriptions derived from it, does provide useful guidance for R&D collaboration managers, it does have a number of shortcomings. Firstly, it tends towards universalistic prescription,[23] a somewhat 'one size fits all' approach which does not deal adequately with the contingencies involved in cross-sector R&D collaborations. Such collaborations are very diverse (e.g. ranging from basic research contracts with clearly-defined objectives through to long term collaborative programmes with more vague and flexible objectives), and they are negotiated and conducted within a variety of contexts, so the contingencies arising from these disparate circumstances need to be incorporated in any 'good practice' model (i.e. to address the question: good practice under which circumstances?). Related to this observation is another shortcoming: that the framework does not address the specific issues associated with collaborative ventures that focus on the commercialisation of knowledge. These collaborations introduce significant tensions for the partners, and more specific guidance is required on how to deal with these than can be provided in a generic 'good practice' model (i.e. which has such general statements as 'ensure mutual benefit'). Thirdly, the model focuses on university/industry collaborations and does not consider the role of intermediaries, such as the CRCs and other government agencies, which can significantly influence the dynamics of a cross-sector collaboration (e.g. by providing a distinctive framework—of rules, roles, procedures and contributions—within which the collaboration will occur).

To address these shortcomings in the existing literatures and provide practical guidelines for micro-level management decisions taken at the time a cross-sector R&D collaboration is designed, we formulated the framework below. Our starting point was to note that cross-sector collaboration brings together participants with quite different interests, objectives, modes of operation, capabilities, timeframes, and commitments. In building an effective collaboration, i.e. which produces useful knowledge and balances the (often-conflicting) interests of the participants, a number of potentially contentious issues or tensions need to be resolved.

Four Tensions in Cross-Sector R&D Collaboration

1. Addressing the Problem of Non-aligned Timeframes

Knowledge that becomes available too late, or that requires significant time to absorb and act on may not be practically useable for companies. Public sector agencies and companies operate according to quite different timeframes, although as the former become more 'businesslike' in their mode of operation (e.g. universities acting as educational service providers selling 'products' to 'customers') this difference may be diminishing. These underlying rhythms can intrude on collaborative projects, inhibiting access to key people and causing unwanted delays. For example, universities are driven primarily by the teaching timetable of the academic year, with its terms or semesters, and by the sometimes extended cycles of publication (i.e. it may take from three to five years, or even more, from the time a study was conducted to when the first journal articles arising from it appear in print). Academics are required to juggle the conflicting demands and disparate time pressures of teaching (typically term bound in blocks of 14 weeks), research (for a study funded by an external grant this will be typically of one to three years duration), and administration (i.e. that arising from teaching, collegial decision-making processes and university governance). These pressures have been exacerbated more recently in Australia by the increase in off-campus and overseas teaching, which can expand the time devoted to teaching at the expense of research activities.

Companies, on the other hand, are more focused on financial reporting periods (i.e. monthly variance reports, quarterly and annual financial statements), the operational time pressures arising from the needs of customers under conditions of competition (e.g. in the area of product innovation, reducing the 'time-to-market' for new products has become increasingly critical in many industries), and the fixed time horizons of projects with clearly-defined 'deliverables'. Thus, company personnel tend to conceptualise time in terms of meeting clearly-defined goals within short-term constraints. In addition, it is suggested here that individual company time horizons are related to product life cycle duration and to company size. Industries with short product life cycles need to get to the market fast (e.g. information and communications technology companies). Others (e.g. pharmaceutical companies) cannot do this until extensive tests are carried out. Smaller companies have a lesser capacity for long term investment, and must obtain economic returns quickly. For all collaborators, time away from the 'core business' (e.g. university teaching, company sales and production) impacts on that business, but in collaborative arrangements, the provision of the time of key people, not just funding, is critical to its success.

However, time is also increasingly a scarce resource for both academics and company personnel. Researchers, unless they are fully dedicated to a joint project (e.g. under external funding which buys them out of their usual duties), have to carefully manage the time they are able to devote to a collaborative project. The same is true for company personnel, who have to manage their collaborative project involvement alongside 'business as usual' activities. A common response in cross-sector projects is to deploy postgraduate research students, usually PhD candidates. But this is often an imperfect solution, given both the timeframe of a PhD (the time to find the right person, plus between three and four years of research) and the output (a body of text which meets the criteria for an original contribution to knowledge)—neither of which may align with the needs of the company for useable knowledge.

So, in setting up and managing a cross-sector collaborative project, a central problem is for the personnel involved to find the time required to achieve the tasks necessary to meet the project's goals within the allocated schedule, and a central element of this problem is to synchronise the timeframes of all project personnel.

2. Reconciling Divergent Approaches to Knowledge

There is now a large and growing research literature on the motives for companies to collaborate on R&D and the development of new technology. One typology identified three main categories of motive: (a) those related to the particular nature of R&D and the characteristics of technological development (e.g. increased complexity and intersectoral nature of new technologies, reduction and sharing costs and risks of R&D); (b) those related to innovation processes (e.g. technology transfer, technological 'leap-frogging', shortening product life cycle, reducing time-to-market); and (c) those related to gaining market access and the search for new opportunities (e.g. globalisation and entry to foreign markets, expansion of product range, monitoring environmental changes and opportunities).[24] A wide range of other studies has shown that, in pursuing their competitive strategic goals, companies participate in collaborative relationships in order to leverage their own R&D activities, to access complementary resources (notably knowledge, capabilities, and personnel), to exploit research synergies, and to create new investment opportunities.[25] Some studies have shown that collaboration with universities enhances R&D productivity and the patenting activities of companies.[26] In specific knowledge-intensive industries, such as biotechnology and pharmaceuticals, companies have become ever more reliant on public science.[27]

It is clear then that what companies seek in collaborations with public sector agencies is 'useable knowledge', knowledge that can be directly appropriated, applied and commercially exploited, most often in the tangible form of new techniques and tools, new methodologies, new products, and technical solutions to existing production problems. What knowledge is considered to be 'useable' is assessed by industry practitioners against a background of prior experiences, risks associated with its application, and the prospects for enhancing the company's position through its application. Unfortunately, what companies seek and what public sector researchers produce are often quite different forms of knowledge. Academics have traditionally focused on the production of 'certified knowledge'; justified true belief arising from peer review and then publication in scholarly journals where it contributes to the public domain knowledge bases of particular international academic communities. Publication is central to the career development of academics, both as a basis for success in grant applications and for promotion within the university. In the natural and social sciences, particularly, publication is also central to the credibility and reputation of individual researchers within the broader communities of scholars.[28]

The problem arising here is a double-barrelled one. On the one hand, when academics in an industry collaboration produce certified knowledge from their research, as codified in scholarly publications, this knowledge may not be suitable or appropriate for use in industry, e.g. it may not be of a form that can be directly applied or commercially exploited. Furthermore, in this form it is public knowledge, and thus accessible by anyone who can read the journal, rather than proprietary knowledge that can be exclusively exploited by the collaborating partners. On the other hand, when academics participating in a collaboration forgo the

production of certified knowledge and instead commit to producing proprietary useable knowledge, they have to accept that this may not contribute to their career development within universities, nor to their credibility and reputation within scholarly communities. This is not only a problem of obtaining appropriate knowledge from a collaboration, it can also be a potent disincentive for ambitious academics to enter into such collaborations.

3. Balancing Commercialisation and the Production of Public Good Knowledge

Since the 1990s, there has been increasing policy emphasis on technology transfer from public-funded research to the private sector, and on the commercialisation of research conducted in universities and public sector research agencies. Commercialisation is the process whereby research outputs and inventions are commercially exploited in the form of marketable goods and services or production processes (i.e. whereby knowledge is translated into commodities). There is a narrow view and a broader view on what constitutes the commercialisation of research. The narrow view, one that has tended to dominate in policy debates, focuses on the protection of new intellectual property and the exploitation of this by way of new products and spin-off companies. A broader view of commercialisation, based on a view of innovation as '… complex, uncertain, somewhat disorderly and subject to changes of many sorts …',[29] acknowledges a wider range of less tangible economic benefits that can arise from research.[30]

Through this increasing focus on commercialisation (mostly construed in a narrow and instrumental sense), research activities in public sector agencies are drawn more and more towards market ends, and they are becoming more driven by a concern to protect research products as 'intellectual property'. This formal granting of property rights enables researchers to retain control over their products (i.e. by providing the legal means to deal with unauthorised usage of this property), and it provides the potential to derive economic benefits over a defined period of time from this property. This approach, and the associated issues of maintaining secrecy with respect to what becomes proprietary knowledge (e.g. it is important in patenting to establish the claim of novelty), is quite at odds with the traditional approach of academic research with its orientation towards research outcomes as a 'public good'. Indeed, the notion of 'intellectual property' as a commodity, traded like other commodities in markets, is the very antithesis of scholarly endeavour. In a university environment, much research is driven by curiosity and the interests of a scholarly community, with little consideration for market opportunities (although under fiscal pressures, this may well be changing). Another problem from a university perspective is the possibility of a dilution (or even a contradiction) of their 'public interest' role. For public sector research agencies, this is typically a requirement under establishing legislation to carry out research 'in the national interest' in order to pursue national socio-economic objectives. For universities, this role is to provide education and training (thereby creating 'human and intellectual capital' and making universities 'the core institutions of the knowledge sector'), and to generate and disseminate knowledge as a 'public good'.

The trend for public sector organisations to become increasingly involved in collaborative ventures that are oriented towards commercialisation has a number of significant implications. In the first place, it has implications for the institutional rules and conventions under which research takes place.[31] A number of researchers have already identified fundamental changes in contemporary science and

technology. Ziman has described the changes as a 'radical, irreversible, world-wide transformation in the way science is organized and performed'.[32] Gibbons *et al.* have postulated the emergence of a 'new mode of knowledge production' ('Mode 2') in which scientific research is carried out more in a context of application (rather than being focused on problems of interest to a scientific community), and which is more heterogeneous and transient in its organisational forms (as opposed to the hierarchical and discipline-based nature of conventional science).[33] The associated institutional changes have affected the core activities and norms of research communities, thereby raising issues about the appropriate role of publicly-funded research.[34] Another implication here is the possibility of international cross-sector collaborations undermining the 'national interest' role of public sector agencies, e.g. by creating or transferring intellectual property to overseas companies and thereby causing economic disadvantage to local companies.

Industry quite often has a different view of intellectual property, regarding the substantial background knowledge of a university as evidence of competence to enter a collaborative venture, but of no higher value than the other kinds of background knowledge that the industry participants bring to the table. Nevertheless, both parties need to bring their knowledge to the collaboration in such a way that it can be shared and enhanced. But note that most firms believe in a 'golden rule'—if we pay the gold, we make the rules. Most public sector agencies now have standard forms of agreement aimed at protecting their background intellectual property, and making new knowledge from a collaborative venture available for internal use such as teaching. A common outcome is that, even when the parties have jointly won a government grant for a new programme, formulating a contractual agreement can take a very long time, or the programme may be abandoned when agreement cannot be reached. Another outcome can be that, whilst some form of agreement is indeed reached, it may be unworkable, making knowledge from the collaboration unusable in practical terms.

The problems here, then, are those of encouraging public sector researchers to become involved in collaborative research with industry, of establishing effective mechanisms to achieve and facilitate the commercialisation of research, and managing the intellectual property created through this research; and to do so in a way that meets the needs, and addresses the concerns, of both sectors.

4. Achieving Common Understandings: Collaboration across Divergent Cultures

Fundamentally, cross-sector collaboration involves two quite disparate organisational cultures learning to work together to achieve jointly-agreed goals. The cultural differences between companies and the public sector are quite marked, each having distinctive management styles and decision-making processes. Personnel in each, often drawn from distinct practitioner cultures, use somewhat different language, their performance is evaluated in very different ways so they are motivated by quite different incentives and rewards, and their work is organised in very different ways. Not surprisingly, these cultural differences can be a source of problems in collaborations, especially those involving universities and these may lead to misunderstandings.[35] A number of studies in Australia have revealed that these cultural differences are recognised by collaborating university and industry personnel, and they are seen by them to be problematic.[36]

In addressing this issue of cultural differences, and the problems it leads to in collaborations, the building of trust among the partners would seem to play a

significant role. The concept of trust has had a long history in organisational studies, and it is now generally agreed that trust is an essential prerequisite for collaboration between organisations, especially for those which involve high levels of uncertainty about outcomes, as is the case with R&D projects.[37] It is only where relationships are based on reciprocal trust that the uncertainties in innovation processes can be reduced sufficiently to allow a free flow of information between the partners and the potential for opportunistic behaviour by any of the partners can be limited. But at the institutional level, public sector and industry partners often find themselves at a loss as to how to develop long term, trust-based relations.[38] One of the major problems facing universities in particular is the change in institutionally-sanctioned forms of trust.[39] Once commercial ventures are entered into and the researcher gains financial rewards from these collaborations, the university loses control over how collegial relations develop, the academic output essential to credentialism, and intellectual property entitlements. These are all undermined by the secrecy demanded of commercial research and the financial hold that external funders have over researchers. It has been argued that the very things that contribute to academic credibility, such as publication, peer review and public presentations of research, are 'up for grabs' in cross-sector collaborations. In other words, the commitments demanded by universities of their researchers are not easily accommodated when confidentiality, ethics and accountability become contested in such collaborations.

The core issue here is that of building effective working relationships based on mutual trust and common understandings of the knowledge being produced (e.g. its distinctive characteristics and potential value in different domains), which in turn will influence perceptions of risk among the collaborating partners. This requires that cultural differences are addressed, and especially differences in the use of language arising from disparate organisational and practitioner cultures, to help foster trust and to ensure that misunderstandings about the collaboration do not arise. Misunderstandings arising from cultural differences can be a source of risk perceptions by particular partners that impede effective collaboration and the successful utilisation of the knowledge produced.

The Proposed Management Framework

As noted above, the framework resulted from a marriage of two distinct viewpoints, one from industry and the other from academia. While both focused on the same end, a practically-oriented concern with how problematic issues can be dealt with in cross-sector collaborations, the starting points were somewhat different. Thus, from an industry perspective the problem was seen as that of overcoming the factors which inhibit university/industry collaborations in Australia and this required 'a balancing of academic and industry values and drivers'. On the other hand, from an academic perspective the problem was seen to be that of a fundamental 'clash of cultures' across the sectors and this gave rise to a number of tensions between the collaborating partners that had to be managed. There was, however, considerable convergence on the key problematic issues involved: differences in operational timeframes across the sectors, the different knowledge orientations in industry and academia, the management of commercialisation and intellectual property rights in cross-sector projects, and the vastly different cultures of companies and universities. These were four issues that both authors had experienced in collaborative projects, and they were issues that were widely considered to

be problematic among researchers and research managers. So, while the desired outcome was clear (i.e. 'to develop some operational design guidelines for successful collaboration', or from a business perspective 'to establish guidelines for confronting the underlying issues so that significant value can be added faster'), how to effect the necessary integration of viewpoints and so achieve the desired outcome was not initially clear.

The resolution came from the adoption of a particular focus, that of 'useable knowledge'.[40] According to this approach, an effective collaboration was one which not only meets its objectives, delivers benefits to all the parties and avoids any negative consequences, but also provides a platform for future collaboration. The generic rationale, or overarching purpose, for entering into an R&D collaboration was seen as the sharing and/or creation of new knowledge for the benefit of the participants. That is, while all such collaborations are formed to fulfil specific objectives, and hence each has a unique focus, the common factor is knowledge creation for mutual benefit which we have called 'useable knowledge'. This perspective has two main advantages. Firstly, it brought into focus a major problem in cross-sector collaboration, that the partners may have different (but often unstated) views on what useable knowledge is and on how it should be produced. Thus, from an industry point of view, useable knowledge is that which is (a) timely in its production so that current needs and problems can be addressed; (b) practically useful, i.e. is in a form that can be applied to technical problems and commercially exploited; (c) in a form that can be treated as proprietary knowledge (notably can be captured and protected as intellectual property); and (d) compatible with the industry partners' competencies, i.e. is adequately understood and of acceptable risk when applied. By contrast a public sector view of useable knowledge, while acknowledging the requirements of practical and commercial utility, is also concerned that its production (a) can be synchronised with industry needs given that the knowledge production process is often longer than the business timeframe; (b) does not erode researcher career paths and the knowledge bases of scientific communities; (c) would be compatible with the production of 'public good' knowledge; and (d) would not undermine the distinctive social features of scientific cultures, i.e. the social mechanisms involved in the production, certification and dissemination of scientific knowledge.

The second advantage of this knowledge focus is that it enabled us to restate the cross-sector tensions in terms of mutually-useable knowledge and thereby indicate the management actions required in order to achieve this.

(a) Organisations in the different sectors have non-aligned timeframes—the timeframes of collaborative projects which seek to produce useable knowledge should be synchronised among the partners.
(b) Useable knowledge is both valid and exploitable—industry needs for commercially-exploitable knowledge should be balanced with scholarly activity.
(c) Useable knowledge is readily accessible to the collaboration partners—the production of tradable assets (e.g. in the form of intellectual property) should be balanced with scholarly activity (e.g. in the form of journal publications), and the impact of project participation on researchers and their career paths should be managed.
(d) Useable knowledge is commonly understood among the collaboration partners—in the collaboration, issues of differing jargon, culture and perceived risk should be identified and addressed.

It is our central argument that, by addressing each of these areas of management action at the time a decision to enter into a collaboration is made, the major problems which can cause the failure, or otherwise qualify the success, of a cross-sector collaborative venture can be pre-empted. Having provided a basis for identifying the critical issues to be addressed in an effective collaboration, the second dimension of the framework posed a typology of possible management responses. These were derived from the literature and from our own experiences. Seven distinct types of management action, as responses to the problems encountered in cross-sector collaborations, have been identified.

1. Identify Appropriate Roles for Collaborative Partners

Some companies simply focus on single sector collaborations, and this may avoid some but not all of the issues raised here. In a study involving more than 4,000 innovative firms in Europe and Australia, interorganisational collaboration was widely practised (i.e. by the majority of firms in Europe, and a little less than half in Australia).[41] However the most likely collaboration partners were other businesses such as lead customers and key suppliers (more than 40%), and the least likely partners were universities and research bodies (less than 20%). Another study of collaborative industrial R&D projects suggested that firms collaborated with other firms primarily to share risks and resources, and to reduce development times.[42] Collaboration with universities was focused on fostering creativity, accessing public funding, leveraging human resources, and accessing specialist facilities. The implication of this study was that a university may not be the best partner to help convert knowledge into a new product or process. Studies such as these underline the importance for firms to be clear about what they expect to obtain from a collaborative partner, and that different collaborative partners may play different roles in the innovation process.

2. The Use of Intermediary Mechanisms

The use of intermediary mechanisms, either by establishing an entity and operations separate from the partners, or by establishing an intermediary/broker function as a part of the collaboration, has been successful in some circumstances, as language issues are better dealt with, and the influence of background business rhythms is minimised. Mobilising university intellectual property through the use of spin-off companies is also seen as an intermediary mechanism with a time imperative as such spin-offs have limited budgets and resources, and have to generate an income relatively quickly.

3. Establish Effective Project Management Systems

Effective project management systems and project managers are widely seen as essential. A study of 146 collaborative projects in 97 firms showed this to be a key success factor, with the necessary personal skills of the project manager including diplomacy, powers of persuasion, and the ability to keep all stakeholders fully informed.[43] The projects that worked best also had strong home base support in terms of collaboration being a company strategic direction, with written policies about its implementation and ongoing management. In a similar vein, research into global networks and virtual organisations has identified the need to formalise three project management roles, i.e. those of co-ordinator, collaborator and communicator, as a central requirement for successful projects.[44]

4. Introduce Staff Exchanges

One way of breaking down cultural and language barriers that has been found to be effective in other contexts (e.g. cross-functional project teams) has been the reciprocal exchange of staff. The European/Australian study referred to earlier noted that staff exchange was a common practice, generally for periods of 15–20 days.[45] Another study showed that technology-enabled communication (e.g. e-mail, videoconferencing) was very effective in supporting distributed teams, as were short exchanges of less than three weeks.[46] Longer term staff transfers were also effective, but were less frequently practised. By contrast, some traditional project management practices such as cost allocation, hierarchical decision-making, use of expert departments, and the appointment of one world-wide leader were found to be less effective in a collaborative environment.

5. The Use of Well-Winnowed Project Agreements

A major sticking point in the establishment of collaborative ventures has been obtaining a project agreement that is acceptable to all parties, especially on such potentially contentious issues as intellectual property and its commercial exploitation. While there is a propensity for the partners to negotiate a unique agreement for each collaboration entered into, there do exist well-developed generic models or 'templates' that have been the basis of successful cross-sector collaborations and which can be customised to suit a particular context. This approach has been taken in an international series of R&D programmes,[47] where general and project-specific agreements have been worked out by academic and industry partners around the world over a number of years, and acceptance of which becomes a pre-requisite for participation.

6. Focus on Relationship Development and Trust Building

There is certainly evidence that comprehensive cross-sector collaborations are valuable, but that they take a long time to evolve without some kind of intervention. A review of six successful long term collaborations of different kinds at the University of New South Wales has suggested that it takes about nine years for a relationship to mature, starting with a small project, developing through joint access to government grants to more direct industry funding.[48] In today's environment this is seen by industry to be too long. One of the issues to be dealt with in speeding up the evolution of a successful collaboration is the rapid development of trust. This issue has arisen in research into virtual enterprises and networks where a number of suggestions were put, including (a) prior accreditation by an independent authority to certify that a potential partner has the capability and means to undertake a particular task; and (b) on the basis that trusting another party can be a risky business (especially where that trust exposes an organisation to the possibility of exploitation or loss of proprietary knowledge), developing a rigorous and open risk management process to address the concerns of the participants.[49]

7. Use Focused Presentations to Build Executive Support

At the other end of the time spectrum, for collaborative projects to gain support, and subsequently be judged as potentially successful by industry, very focussed and

succinct presentations outlining the benefits and future possibilities of a collaborative project have to be put to executive managers. Such presentations should be developed and presented jointly, and it may be necessary to engage in some independently-facilitated scenario development to characterise potential future benefits arising from the collaboration. Such speculation and brevity is sometimes criticised by researchers, but if a clear focus cannot be demonstrated, nor potential benefits to industry identified, an impression of uncertainty or incompetence may be conveyed, leading to perceptions of too much risk in the collaboration.

These are just some of the strategies that have emerged to deal with the problems in cross-sector collaboration, and our treatment of these here is necessarily brief. Basically these strategies, aimed at building effective collaboration across sectors, fall into three main categories: (a) the clarification of the roles of the different collaborative partners, thereby ensuring that partners play roles appropriate to their capabilities and resources; (b) the use of intermediary mechanisms to mediate between the sectors and otherwise manage the cross-cultural issues; and (c) the establishment of mutually-agreed rules, procedures and systems to manage the relationship, build trust and facilitate collaboration. These strategies may be deployed individually or in some combination, and their application will be dependent on the specific context of a collaboration. In Figure 1 we have related the three categories of response strategy to the four main knowledge issues as an initial illustration of how this framework can be used to identify the means by which cross-sector collaborations can be successfully established and managed.

Applying the framework, collaboration designers first identify the key knowledge-related issues likely to be problematic among the partners and they then draw on each of the response categories to identify management actions which will address each of these. In negotiating the problematic issues and appropriate responses, the designers will eventually populate the matrix thus creating a 'blueprint' for the collaboration. Note that the framework provides guidance

Response strategy *Knowledge issue*	Establish collaboration roles & scope	Establish intermediary mechanisms	Establish collaboration rules & procedures
Timeliness of knowledge.			
Applicability & exploitability of knowledge.		Action(s) to deal with identified knowledge issue.	
Accessibility of knowledge created.			
Common understanding of knowledge created.			

Figure 1. The proposed management framework for cross-sector R&D collaborations.

rather than prescription. That is, it does not provide any rules or heuristics to indicate which issue is likely to be problematic or which response to an issue is most appropriate. These are decisions to be made in negotiation by the collaborating partners, drawing on the framework to focus on the critical issues and identify the means of their resolution.

Discussion and Conclusion

In this paper we have sought, in a preliminary way, to clarify the nature of the problems associated with cross-sector collaboration in terms of tensions that need to be managed and in terms of the requirements of useable knowledge. We would argue that it is only by addressing these tensions and by ensuring that the knowledge arising from the collaboration is directly 'useable' by the industry partner that the collaboration can be valued by all parties and its outcomes lead to the policy goals sought by Government (i.e. economic growth and development). We have noted that if the knowledge produced is not timely, not readily accessible by industry, or there is some uncertainty associated with it (due to a lack of trust or understanding among the partners), then such knowledge is not practically useable by the industry partner and the collaboration which produced it will not be highly valued by them. Further, if the operational timeframes of the partners are not synchronised, and industry needs for commercially-exploitable knowledge are not balanced with scholarly activity (including consideration of the impacts of project participation on public sector researchers and their career paths), then the collaboration is not likely to be sustainable.

Having delineated the problems confronting cross-sector collaboration (we have argued elsewhere that organisations vary in their capability to manage the tensions and that this can become an important measurable competence in a business context where cross-sector alliances are increasingly critical[50]), we have also sought to identify some practical solutions to these problems and to provide a framework for their application. We would conclude by emphasising the preliminary nature of this work. In writing this paper, we have merely opened a research agenda and it is clear to us that much more research is required to provide a more detailed understanding of the dynamics of cross-sector collaboration and of the factors which contribute to collaborative success. From the feedback we have received so far, it appears that the framework does have the potential to help R&D managers design effective cross-sector collaborations. Certainly the specification of cross-sector tensions in terms of mutually-useable knowledge is both appropriate and useful in that it does seem to help managers engage with the key problematic issues. But while the management response categories do seem to be appropriate (the degree to which they are comprehensive remains unclear), the framework as currently configured does not provide sufficient guidance on how to address the identified problems. In sum, we would conclude that the framework has so far been partly validated in our preliminary research,[51] but clearly further work is required.

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