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Evaluating the performance of collaborative research and development activities

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Abstract

Collaborative research and development (R&D) activities involve researchers working closely with industry, community and/or other stakeholders to address research problems, as promoted by the Australian Cooperative Research Centre (CRC) Program. Case study analysis of two collaborative research activities undertaken by the CRC for Sustainable Sugar Production has identified some important positive and negative features of collaborative research. These findings and the results of a survey of CRC Sugar stakeholders will contribute to the development of a framework to systematically evaluate the performance of collaborative research activities. The proposed evaluation framework is expected to contribute knowledge regarding the value of collaborative research, as well as benefit researchers, stakeholders, funders, and research managers, and allow them to improve the efficiency and effectiveness of collaborative research activities.

Keywords

research evaluation, collaborative research, sugar, Co-operative Research Centre (CRC), performance evaluation

Introduction

The purpose of this paper is firstly to highlight the need for research to investigate the attributes of collaborative research within the agricultural and natural resources sector, and secondly to present some key findings of research undertaken to contribute knowledge regarding the value of collaborative research.

This paper presents an overview of the evolution of agricultural and natural resource research and development (R&D) activities, and of particular interest is the evolution of collaborative R&D as advocated by the Australian Cooperative Research Centre (CRC) Program. A brief overview of the evolution of evaluation approaches is also presented, and the need to develop an evaluation approach for application to collaborative research at the project level is highlighted. Key empirical findings of two case study collaborative research activities, selected from the CRC for Sustainable Sugar Production (CRC Sugar) are presented. The findings add to the existing literature on the value of collaborative research. Plans for future research are presented, and expected benefits of this research are documented. The findings and ideas presented in this paper are envisaged to be of value to researchers and other participants in collaborative research activities, industry, community, as well as research fund managers and policy makers.

Collaborative research – background and definition

Collaborative research is subject to multiple interpretations within various disciplines and across disciplines, and is often not clearly understood (Bond and Thompson 1996; Katz and Martin 1997). The definition of collaborative research adopted within this paper is research undertaken involving researchers and stakeholders such as industry, community, professional or government representatives, as per the CRC model. The advent of researcher-stakeholder collaboration is linked with the emergence of farming systems research in the 1960s, which aimed to bridge the gap between the needs of small resource-poor farmers and publicly funded agricultural research establishments (Collinson 2000).

The Australian CRC Program was launched in 1990 to strengthen collaborative research links between industry, research organisations, educational institutions and relevant government agencies in order to obtain greater benefits from Australia's investment in R&D (<http://www.crca.asn.au> 24/1/02, Mercer and Stocker 1998). The establishment of the CRC Program reflects the recent development of policies worldwide to encourage collaborative research across a wide range of research areas (Sikka 1998; Rosenberg et al. 1999; The Council on Food and Agricultural and Resource Economics 1999; Godin and Gingras 2000; Okubo and Sjoberg 2000).

The CRC for Sustainable Sugar Production (CRC Sugar) was established in 1995 and is an unincorporated joint venture comprising 13 parties which represent the growing and milling sectors of the sugar industry, publicly funded research support agencies, research organisations and universities. Further details of the advent of collaborative research, and a brief historical overview of sugar research in Australia, outlining the major research institutions and type of research undertaken over the past century were presented in a previous paper (Henderson 2001).

Growth in collaborative research is evident worldwide, and it is widely perceived this form of research is a valuable and beneficial mode of research. The trend towards increasing collaborative research has been apparent for some time without any formal or objective analysis of the value of collaborative research. There is a need to evaluate collaborative research to ensure the trend toward increasing collaboration can be justified. Furthermore, evaluation may also lead to improvements in the management, conduct, and outcome of collaborative research as greater understanding of the various factors contributing to a successful and efficient collaborative research activity are developed.

Evaluation – approaches and disciplines

Evaluation paradigms and approaches have evolved significantly over the past century, and a variety of approaches have been developed, drawing on a range of disciplines, to meet the particular objectives of an evaluation. An overview of the paradigms and approaches applicable to the evaluation of programs or activities is presented within this section.

Despite evaluation being recognised as a professional area of activity, there are various interpretations of the term *evaluation* (Dart et al 1998; Sapin 1997). From a utilitarian perspective, evaluation is defined as assessing the merit or worth of a particular activity (Scriven 1991). However, during the 1970s and 1980s, the field of evaluation evolved to include a range of program-related characteristics such as need, process, logic, and cost-effectiveness (Pancer and Westhues 1989).

One principal characteristic of evaluation is that numerous prevailing research paradigms are recognised as providing important contributions (Rossi et al. 1999). The primary disciplines included in evaluation are reported by Rossi et al (1999) as including education, psychology, statistical methods, sociology, economics, political science and organisational development.

A wide variety of evaluation approaches and techniques have been developed reflecting a range of philosophical perspectives of the evaluators. However, a problem-solving sequence intrinsic to evaluation was identified by (Shadish et al. 1995 p 20) and includes:

- (a) identifying a problem;
- (b) generating and implementing alternatives to reduce its symptoms;
- (c) evaluating these alternatives; and
- (d) adopting those that results suggest will reduce the problem satisfactorily.

Each evaluation approach is designed to meet a range of specific objectives. Owen and Rogers (1999) developed a conceptual meta-model that classifies evaluation approaches into five forms based on purpose and orientation, as summarised in Table 1.

Table 1: Owen's five forms of evaluation

Form	Orientation	Brief overview
A: Evaluation for program development	Synthesis	This form of evaluation is typically undertaken <i>ex-ante</i> , or prior to the commencement of a program, to identify the needs of stakeholders, and focus on defining the program context, including objectives. Commonly referred to as a needs assessment or setting a benchmark.
B: Evaluation for design clarification	Clarification	This form of evaluation is ongoing during the development of a program and focuses on all aspects of the program. Key findings of a clarificative evaluation include a program plan and implications for stakeholders in the program.
C: Process Evaluation	Improvement	This form of evaluation is ongoing during the development state of a program, and focuses on delivery and improving the program as it progresses.
D: Evaluation for program management (monitoring)	Accountability /Finetuning	This form of evaluation is typically undertaken during the program, and is useful to justify and/or fine-tune the program to improve delivery and outcomes.
E: Evaluation for impact assessment	Justification	This form of evaluation is undertaken <i>ex-post</i> or following the completion of a program, to assess the impact of a program for justification or accountability. Assessment of whether the objectives of the program have been met.

Derived from Owen and Rogers (1999)

Evaluation practitioners comment that many evaluation studies span more than one of Owen's five forms (Dart et al. 1998). However, this categorisation is a useful framework to consider systematically the main purpose and orientation of a particular evaluation.

The distinction between formative and summative evaluations is another useful categorisation of evaluation approaches (Scriven 1991). *Formative* evaluation is defined as an evaluation conducted during the development of a program or product with the intent to improve. *Summative* evaluation is conducted after completion of the program and for the benefit of some external audience or decision-maker.

Scriven (1991) also distinguishes between partial and global (or holistic) evaluation. *Partial* analytical evaluation involves evaluating parts or aspects as a means to an overall evaluation. *Global* evaluation involves the allocation of a single score or grade for evaluation of the overall character or performance of a program or product. In some cases global ratings are more accurate, and evidence exists that the analytical approach is not 'more scientific' and hence better (Scriven 1991).

Quantitative and qualitative are terms commonly used to describe evaluation approaches. *Quantitative* evaluation usually refers to an approach involving a heavy use of numerical measurement and data analysis methods. *Qualitative* evaluation

refers to the part of evaluation that can not be usefully reduced to quantitative measures, and where description and interpretation is undertaken instead of more quantitative analysis. Over time there has been a gradual convergence of the quantitative and qualitative approaches (Scriven 1991).

Taking a wider perspective of evaluation approaches, there has been a trend over recent decades toward pluralistic evaluations which embrace diverse perspectives, methods, data, and values to generate more insightful and meaningful evaluative statements (Greene and Caracelli 1997). Greene and Caracelli (1997) outlines three positions within the pluralist debate:

1. the *purist* position against mixing paradigms;
2. the *pragmatic* position whereby paradigms are useful conceptual constructions but practical methodological decisions are based on contextual responsiveness and relevance thereby often including diverse methods; and
3. the *dialectic* position whereby paradigms are important guides for practice and the inevitable tensions that arise from comparing and contrasting paradigms are regarded as potentially generating more insightful, evaluative understandings.

The evolution of evaluation techniques over recent decades has also been presented in Guba and Lincoln (1989). Four generations of evaluation are documented:

1. First generation evaluation, or measurement;
2. Second generation evaluation, or description;
3. Third generation evaluation, or judgement; and
4. Fourth generation evaluation, or negotiation over content and purpose.

This brief overview demonstrates that the field of evaluation has developed significantly, that evaluation approaches have developed to meet a variety of purposes, that evaluation experts support a range of paradigms, and that evaluation includes a wide range of disciplinary perspectives. Knowledge of the various evaluation paradigms, approaches and their attributes is critical to the selection of appropriate evaluation technique to address a particular problem. "Good evaluation is not about learning a few methods, more about understanding the concepts of program evaluation and being able to pick and choose from a wide range of tools to meet particular needs" (Dart et al. 1998). Furthermore, the merits of using dialectic, pluralist evaluation approaches that incorporate a range of perspectives and paradigms are recognised and documented.

Application of evaluation approaches to agricultural and natural resource R&D activities

A brief overview of the use of evaluation approaches in the agricultural and natural resource R&D sector is provided within this section. There is some emphasis on the implementation of evaluation approaches within the sugar industry research sector.

The evaluation of R&D activities in agricultural and resource management has been given significant attention within the discipline of agricultural economics. Economic research evaluation approaches have developed primarily to address accountability and resource allocation objectives (AACM International Pty Ltd 1997; Alston et al. 1999). Since the 1930s, increasing effort has been directed to assessing the economic

impact of agricultural and natural resource R&D activities, to aid resource allocation decisions and to demonstrate accountability and/or justify research expenditure (Perkins 1994; Alston et al. 1999). Benefit-cost analysis (BCA) is the most frequently-used method of economic evaluation (Sinden and Thampapillai 1995). Numerous references outline the economic principles associated with estimating economic returns to research investment (Alston et al. 1999; Perkins 1994; Sinden and Thampapillai 1995).

The use of economic evaluation approaches, and in particular the use of BCA techniques, to determine the economic impact of investments in agricultural and natural resource R&D appeared to peak in Australia during the 1990s. This is evidenced by a major workshop entitled “Economic evaluation of agricultural research in Australia and New Zealand” held in 1996 in conjunction with the 39th Annual Conference of the Australian Agricultural Economics Society (Brennan and Davis 1996). A special interest group REGAE (Research Evaluation Group for Agricultural Economists) was established at the workshop, and published 14 issues of REGAE News containing information and debate on a wide range of research evaluation topics. In 1998, the group decided there was insufficient value in continuing the newsletter, and the group is now inactive (<http://www.general.uwa.edu.au/u/aares/regae.htm> 7/2/02). From the early 1990s, research submissions to a range of rural Research and Development Corporations required the results of an *ex-ante* BCA to be included, as this information was considered useful to resource allocation decision making.

Contributions to numerous AARES Annual Conferences, and other similar conferences internationally, focused on the economic assessment of research outcomes. Published work within the Australian Journal of Agricultural and Resource Economics, and similar journals internationally, also focuses on this topic. Pannell (1999) highlighted the unprecedented interest in formal economic evaluations of agricultural research in recent times.

Within the CRC Program, economic evaluation of the investment in CRC research is undertaken to meet accountability objectives. The 2001 CRC Association Conference theme was “Returns to R&D Investment” with considerable emphasis on presentation of results of *ex-post* BCAs of CRC Program research activities. Many CRC entities and rural Research and Development Corporations have undertaken *ex-post* impact assessments of research expenditure using BCA techniques. Within the sugar industry, application of BCA techniques to the evaluation of research activities is evident in both research and independent consultancy work (Agtrans Research and eSYS Development 2000; Agtrans Research and eSYS Development 1998; McLeod 1996).

In light of the previous section documenting the wide range of evaluation paradigms and approaches, the economic assessment of agricultural and resource R&D focuses predominantly on evaluating impact in a *summative* manner.

Evaluation approaches other than economic analyses have been applied to agricultural research activities. In particular, efforts have focused on understanding and evaluating the extension of research results to stakeholders and industry. This is evidenced by the large number of evaluation studies and other publications on this

topic within the agricultural extension and advisory area. A recent review of evaluation techniques applied to agricultural extension was presented by Dart (Dart et al. 1998). Numerous models of evaluation have been developed among the research and extension activities servicing agricultural and resource research and extension sectors (Roberts 1998; Carberry 2001; Rogers and McDonald 2001; Chamala et al. 1999; Cramb and Purcell 2001). Some key evaluation approaches applied to agricultural extension activities include: Bennett's hierarchy; Rapid Rural Appraisals; action learning; BCA; benchmarking; performance audit (Chamala et al. 1999; Dart et al. 1998). However, it is perceived by Dart et al (1998) the application of evaluation approaches to agricultural extension programs in Australia has been relatively stagnant, standard in method, and under-used.

A search of the literature, and of the practices adopted by research organisations, has revealed there is no evaluation framework suited specifically to the holistic evaluation of collaborative research activities, according to the CRC model. A consultancy project is underway to investigate the quantitative and qualitative outcomes of the CRC Program at a strategic level (Garrett-Jones, S. 2002, pers. comm.), which will add to existing evaluations of the CRC Program undertaken at a strategic level (Mercer and Stocker 1998; Report of the CRC Program Evaluation Steering Committee 1995). At the activity (or project) level in particular, it is uncertain what the value of collaborative research is, and how to monitor and improve this mode of research using *formative* evaluation techniques. The need to develop an answer to the question "what is the value of collaborative research?" is highlighted in the literature by Katz and Martin (1997), Nelson (2000), and Goldstein (2000). Further, Cullen et al. (1999) note that many collaborations do not meet their potential and that the opportunity exists to improve the performance of collaborative research activities.

"A systems view of research is a holistic one which implies that an isolated study of parts of the system will not be adequate to understand the complete system because the separate parts are linked in an interacting manner" (Dent, 1971 quoted in Brennan 1998 p 3). This same principle can be applied in the evaluation of research activities, in particular, evaluation of a new mode of research such as collaborative research. We can understand one part of the complex system through undertaking an economic impact evaluation, for example, but systems approach, incorporating more than one discipline will be of benefit in understanding the complete "system" of collaborative research. Development and application of a pluralistic, dialectic model of evaluation for collaborative research activities is envisaged to fill the existing gap in knowledge, and provide a framework of value to researchers, stakeholders, funders and research managers in improving the efficiency and effectiveness of collaborative research activities. It is envisaged a *summative* approach to evaluating collaborative research activities would be useful in producing knowledge of the eclectic value of collaborative research, and a *formative* approach to evaluating collaborative research activities would be useful to improve the performance or process, efficiency and effectiveness of collaborative research

Collaborative research case studies

Research undertaken to identify the key attributes contributing to the performance of collaborative research activities is reported within this section. To identify attributes

of CRC collaborative research activities, case study research was identified as the most appropriate research method. Case study research is an exploratory form of research, and involves the investigation of a phenomenon within its context (Yin 1993; Yin 1994). The case study approach assumes that by studying a particular complex problem in detail, and within its context, the problem will be understood and explanation and/or evaluation of the problem and issues can be made.

Two collaborative research activities were selected from CRC Sugar as case study activities. The main purpose of the case studies was to provide insight into the factors contributing to successful collaborative research. The first case study selected was entitled “Dam Ea\$y”, and was an ongoing research activity aimed at assisting cane growers in the Bundaberg region with the decision of investing in on-farm water storage structures. The second case study was CRC Sugar Activity 1.3.4 entitled “Interactive farm-scale survey of acid sulfate soils in NSW canelands” aimed at reducing acidic drainage discharging into waterways and contributing to environmental problems.

For each case study, personal interviews were held with participants and stakeholders and, where possible, attendance at workshops, meetings and field work associated with the activity. As a result of the two case studies, and a literature review, a long list of factors contributing to the success of collaborative research activities and acting as barriers to successful collaboration were identified.

The factors contributing to the success of collaborative research activities could be categorised according to:

- the relevant discipline, such as economics, management, sociology;
- the hierarchical level of decision making each attributes contributes, such as individual level, activity or project level, program level and/or organisational level;
- the stage in the research cycle the attribute is relevant to, such as administration and management, process, and/or impact; and
- the purpose of evaluation, such as synthesis, clarification, improvement, accountability/finetuning and justification.

Within this paper, the factors contributing to the success of collaborative research activities are grouped by major discipline to highlight the extent and limitations of the contribution each discipline is able to make to the evaluation of collaborative research activities. The major disciplines identified as relevant included economics, management and sociology. Some factors could be categorised within more than one of these three nominated disciplines, and some factors were unable to be satisfactorily categorised within one of the three disciplines. Additional disciplines could have been included in the framework, but were considered of less importance and were not presented within this paper.

The main findings of case study research to identify factors contributing to the success of collaborative research activity are presented in Tables 2, 3, 4 and 5. Table 2 presents economic factors, Table 3 presents management factors and Table 4 presents sociological factors. Several factors contributing to the success of collaborative research activity were not suited to the disciplinary categorisation and these factors are presented in Table 5.

Table 2: Economic factors contributing to the performance of collaborative research activities

Factor	Case study findings	Literature review findings
Expected net economic benefit	An external BCA commissioned by CRC Sugar was undertaken to determine the economic returns to investment in one of the case study research activities, and the returns were significantly positive (Agtrans Research and eSYS Development 2000). An attempt was made to quantify the economic returns to investment applying BCA to the second case study research activity, but due to the difficulties associated with quantifying the benefits, a break-even analysis was undertaken. The results indicate the economic benefits of the research activity are likely to be positive.	BCA provides an indication of the expected economic benefits of a particular research investment, and is a useful tool in resource allocation decision making and evaluating the impact of investment in research (Alston et al. 1999). The results of <i>ex-ante</i> BCA are useful in strategic research priority setting, and the results of <i>ex-post</i> BCA are useful in impact assessment. Implicit in BCA are assumptions regarding the adoption of research outcomes by industry. Within the literature it is suggested collaborative research may contribute to faster and/or higher levels of adoption due to industry participation and increased ownership of research results (Chamala et al. 1999).
Transaction costs	Both case study activities incurred significant transaction costs due to the collaborative nature of the research activities. Increased administration is one specific transaction cost of collaboration. One participant in a case study activity indicated participatory research required 2-3 times more time input from researchers than conventional, non-participatory research. The case studies also demonstrated that not all participants were able to attend all meetings due to time commitments elsewhere. Furthermore, researchers, extension agents and industry participants devoted considerable time attempting to secure financial funding, which was considered frustrating for those involved.	Transaction costs, defined as the costs people incur in order to do business with each other, are highlighted in the literature as associated with the conduct of collaborative research activities (Katz and Martin 1997). Collaboration brings certain costs in terms of increased administration, and decisions influencing the direction of a collaborative research activity may require considerable time to allow discussion, negotiation and/or consensus between collaborators (White and O'Brien 1999).

Table 3: Management factors contributing to the performance of collaborative research activities

Factor	Case study findings	Literature review findings
Communication	Within the case study activities, communication varied in frequency depending on the intensity of progress, and open communication was evident at meetings.	The literature identifies frequent, open and highly developed communication between collaborative partners as fundamental to the development of an effective collaboration (Bond and Thompson 1996; Cullen et al. 1999; Mattessich and Monsey 1992).

Factor	Case study findings	Literature review findings
Flexibility	The actual research undertaken changed significantly from the original intentions for one case study activity and the activity was considered by participants to be successful because of this.	Flexibility is identified in the literature as an important feature of successful collaborations (Mattessich and Monsey 1992).
Free-riding	One participant in a case study activity expressed concern about one sector free-riding on the efforts of collaborating parties. It was perceived the contribution made by the various participants was not equitable in relation to the expected benefits of the collaborative research activity.	White and O'Brian (1999) highlight the need for <i>all</i> members of a group to work in good faith toward agreement.
Frustration	One cause of frustration evident in a case study activity was the delays experienced in producing research output.	Frustration is inevitable in collaborative research, and compromise and diplomacy are seen as essential in addressing differences (Cullen et al. 1999; Mattessich and Monsey 1992).
Honest-broker role	Comment was made by one participant in a case study about the honest-broker role of researchers. Due to the competing interests of participants in collaborative research activities, researchers may compromise their honest-broker role in some cases.	-
Leadership style	Comment was made by one participant in the case study activity that dictatorship does not work in collaborative research activities.	The benefits of participatory methods are documented in the literature (Chamala et al 1999).
Momentum	It was noted by one participant that momentum was lost during the process of the research activity, and once lost was difficult to regain. Initially, participants were very enthusiastic about the activity but, for various reasons, this momentum was lost and the potential level of achievement of the activity was perceived to be reduced. Factors observed as possibly contributing to this loss in momentum included insufficient funding for the research, competing priorities for time among participants in the activity, and less frequent communication and meetings.	-

Factor	Case study findings	Literature review findings
Participation	Concern was expressed by one participant that the industry representatives involved in the collaborative research activity were also involved in many research activities in that area, and they could be influencing the research agenda to reflect their personal concerns. However, despite the small number of industry representatives participating directly in the research process, a large number of industry representatives were interested in applying the outputs of the research activity. Future adoption of the research results by industry will indicate if the demand and supply for research results has been successfully matched (and drive the net economic benefits of research)	-
Planning	Forward planning was difficult to undertake due to funding uncertainties in one case study activity, and a more flexible approach was adopted.	Mann (1998) highlighted good planning as an essential factor in successful research collaboration.

Table 4: Sociological factors contributing to the performance of collaborative research activities

Factor	Case study findings	Literature review findings
Changes in attitude and perceptions	Changes in industry attitude to environmental issues may have resulted from the collaborative research effort in one of the case studies. This could have spin-off benefits to the adoption of other technologies. A researcher commented that as a result of the research activity, community perceptions of sugarcane growers had changed, and were more positive.	Bennett's Hierarchy is a technique used in agricultural extension evaluation that recognises changes in Knowledge, Aspirations, Skills and Aspirations (KASA) as an important output that may lead later to changes in practice (Chamala et al. 1999). Mercer and Stocker (1998) in their strategic review of the CRC Program identified one of the most important benefits of the Program was changed attitude and perspective in industry and research organisations.
History of collaboration	Individuals in both case study activities had a history of working together.	A history of collaboration at the activity level offers potential collaborative partners an understanding of the roles and expectations required in collaboration, and enables them to trust the process (Mattessich and Monsey 1992).

Factor	Case study findings	Literature review findings
Individual preferences for working in isolation and collaborating	One extension agent commented that the same few growers are involved in collaborative research activities in that particular region, and some growers prefer working in the paddock to work on a collaborative research activity. Some researchers would rather work on developing their specialist knowledge than spend inordinate amounts of time discussing basic and general things with growers.	-
Objectives of participants	The objectives of participants in collaborative research activities differ between individuals, and between types of participant. Researchers may focus on achieving specified milestones, preparing scientific papers and reports, contributing to knowledge, and delivering benefits to the wider community. Industry participants may focus on the industry benefits of the research activity.	Collaborating partners should see the collaboration as in their self interest, and view the benefits of collaborating as significant, and outweighing any negative aspects associated with collaboration (Mattessich and Monsey 1992).
Organisational culture	The case studies exhibited some organisational culture issues but these did not appear to hinder progress. However, adoption of research results by industry may be influenced by the differences in culture between the various groups of participants.	Organisational culture may or may not be conducive to collaboration (Cullen et al. 1999). Culture is defined by Chamala et al (1999) in terms of: <ul style="list-style-type: none"> • people orientation (encouragement, sharing, friendliness); • task orientation (coordinating, implementing action plans); • power orientation (political activity, power cliques) • regulation orientation (justice, rationality, dependability)
Ownership	Ownership of the collaborative research case studies varied between participants, and appeared to depend on the level of involvement of the participants in the research process.	Collaborations are positively influenced by the members of a collaborative group feeling “ownership” of the way the collaboration works, and the results (Mattessich and Monsey 1992).
Personality	Comment was received from one researcher that an important factor contributing to the success of a collaborative research activity was the personality of the individual participants.	Anderson and Hardaker (1992, p121) suggested that “the three most important elements of an effective and efficient agricultural research effort are people, people, and people!” Cullen et al (1999) notes the complexities of interpersonal relationships within collaborative research, and that each contributor brings weaknesses as well as strengths. Many people lack the capacity to work together using a win-win approach (Chamala et al, 1999).

Factor	Case study findings	Literature review findings
Teamwork	Comment was made by one participant in a case study activity that teamwork within the industry has a limited history, and lessons could be learnt from other industries with a history of successful collaboration.	Harvard Business Review (1998) recognises that companies have moved from control-orientated, functional hierarchies to faster and flatter multi-functional teams and that traditional performance-measurement systems not only fail to support these teams but may also undermine them. This movement appears to have occurred within the research sector, as well as the business sector.
Trust	The case studies did not indicate lack of trust between collaborative parties or individuals was hindering the performance of the collaborative research activity.	Trust between collaborating parties or individuals is seen as fundamental. If one party feels the other has taken advantage of them, the collaboration will probably founder (Cullen, Norris et al. 1999; Mattessich and Monsey 1992; White and O'Brian 1999).

Table 5: Additional factors contributing to the success of collaborative research activities

Factor	Case study findings	Literature review findings
Authorship of scientific papers	A participant in one case study highlighted problems with authorship of scientific papers emanating from collaborative research. A scientific conference initially required the number of authors listed on contributed papers be restricted to a maximum of three, although this number was later negotiated.	Bond (1996) identifies authorship may be an issue associated with collaborative research requiring specific management. Bibliometric research in a range of fields has identified a trend to increased co-authorship (Katz and Martin 1997).
Funding	Lack of an adequate, consistent financial base to support research activities was seen to contribute to reduced research momentum. Intellectual resources appeared more readily available than financial resources. In addition, comment was received from one researcher that the time to obtaining funding was often significant. Within one case study game theory could be applied to explain the reluctance of funding bodies to provide financial support for the research activity. The researchers approached a number of bodies in an attempt to secure funds. Reluctance to commit funds to the research was found to be in part due to the lack of commitment from other funding bodies.	Favourable resource control is mentioned in the literature as a factor contributing to the success of collaborations (Mattessich and Monsey 1992). Game theory is a method of analysing strategic behaviour and is a major topic of research within strategic management and economics (McTaggart et al 1995).

Factor	Case study findings	Literature review findings
Intellectual property management	The case studies did not highlight any intellectual property management issues. The CRC Program has recognised that IP may be an issue and provides guidelines for IP management.	The literature highlights management of intellectual property (IP) as a potential area of conflict between collaborating parties (Chamala et al 1999).
Synergies contributing to higher objectives	The main objective of one case study was regarded as unlikely to have been achieved occurred without input from each of the participating parties.	Cullen (1999) states collaboration means actively working together to achieve things which could not be done alone.

Case study research and the review of literature has revealed a wide range of factors contributing to the success of collaborative research activities that can be grouped by key discipline. There are linkages and areas of commonality between the three nominated disciplines of economics, management and sociology, and several factors are unable to be categorised within the three disciplines. However, the grouping of factors according to the major contributing discipline highlights the contribution of each discipline to our understanding of collaborative research. It is clear that a holistic, eclectic approach to the evaluation of collaborative research will contribute knowledge regarding the wider value of collaborative research.

Future research will focus on a survey of participants, managers and funders of CRC Sugar research activities. The aim of the survey will be to clarify and add to the case study and literature review findings. Further, the survey is envisaged to enable prioritisation of factors contributing to a successful collaborative research activity. The case study, literature review and survey results and findings are necessary for the development of a *summative* and *formative* framework for the evaluation of collaborative research activities. It is envisaged a *summative* evaluation of collaborative research from a holistic, eclectic point of view will result in improved understanding of the wider value of collaborative research. Furthermore, it is envisaged a *formative* evaluation framework for use in the evaluation of collaborative research activities will benefit individual participants in collaborative research, as well as stakeholders, funders and research managers by allowing them to improve the efficiency and effectiveness of this form of research.

Summary

There is a need to expand existing approaches to the evaluation of collaborative research activities firstly to improve our understanding of this mode of research, and secondly to improve its conduct, efficiency and effectiveness. Collaborative research has evolved as a popular mode of research over recent decades, and has done so without any formal, holistic, *summative* evaluation of its value. Furthermore, the development of a *formative* framework for the evaluation of collaborative research activities is envisaged to improve understanding of the factors contributing to a successful collaborative research activity, and if implemented, improve the efficiency and effectiveness of this form of research.

Exploratory case study analysis of two collaborative research activities funded by CRC Sugar has been useful in highlighting a wide range of factors contributing to the

performance of the collaborative research activity. Relevant literature has been a useful resource. The majority of factors identified were of a qualitative nature and were grouped by discipline. Future research will focus on confirming and adding to the findings reported in this paper through consultation with CRC Sugar stakeholders. This will enable a *summative* and *formative* framework for the evaluation of collaborative research activities to be developed. It is envisaged that these two research evaluation approaches will contribute knowledge as well as provide practical insights for the improvement in conduct, outputs and outcomes of collaborative research. Benefits of this research are envisaged to accrue to researchers and other participants in collaborative research activities, industry, community, as well as research fund managers and policy makers.

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