Title: The importance of information systems in inter-sectoral R&D collaboration: the case of the Australian co-operative research centre (CRC) program

Author: Gogor Oko Nurharyoko

Year: 2005

Repository DOI:

THE IMPORTANCE OF INFORMATION SYSTEMS IN INTER-SECTORAL R & D COLLABORATION: THE CASE OF THE AUSTRALIAN CO-OPERATIVE RESEARCH CENTRE (CRC) PROGRAM

A thesis submitted
in fulfilment of the requirements
for the award of the degree

Doctor of Philosophy

From

UNIVERSITY OF WOLLONGONG

By

Gogor Oko Nurharyoko, M.Sc.

School of Management and Marketing
University of Wollongong

July 2005

Thesis certification

I, Gogor Oko Nurharyoko, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Management and Marketing, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Gogor Oko Nurharyoko

1 July 2005

TABLE OF CONTENTS

List of Tables and Figures

List of Tables — Page

<u>List of figures</u> **<u>Page</u>**

List of abbreviations and acronyms.

ACIAR	: Australian Centre for International Agricultural Research.
ACSys CRC	: Cooperative Research Centre for Advanced Computational System.
AGL	: Australian Gas Limited (member of APIA).
ANSTO	: Australian Nuclear Science and Technology Organisation.
ANT	: Actor Network Theory.
ANU	: Australian National University.
ANZFA	: Australia New Zealand Food Authority.
APIA	: Australian Pipeline Industry Association.
ARC	: Australian Research Council.
AWB	: Australian Wheat Board.
BHP	: Broken Hill Proprietary Limited.
CEO	: Chief of Executive Officer.
CIMMYT	: *Centro Internacional de Mejoramiento de Maiz y Trigo* (Mexico).
CIO	: Chief Information Officer.
CMIS	: CSIRO Division for Mathematical and Information Science (Australia).
CRC	: Co-operative Research Centre.
CRC MWJ	: Co-operative Research Centre for Material Welding and Joining.
CRC QW	: Co-operative Research Centre for Quality Wheat.
CRC WS	: Co-operative Research Centre for Welded Structures.
CSIRO	: Commonwealth Scientific and Industrial Research Organisation (Australia).
DEC	: Digital Equipment Corporation.
DIST	: Department of Industry, Science and Technology (Australia).
DMME	: Department of Mechanical and Mechatronics Engineering (of UoS).
DoD	: Department of Defence (Australia).
DSTO	: Defence Science and Technology Organisation (Australia).
EDI	: Electronic Data Interchange.
ElCom	: Electronic Communications.
EU	: European Union.
GDP	: Gross Domestic Product.
GIRD	: Grants for Industry Research and Development (Australia).
GRDC	: Grains Research and Development Corporation (Australia).
HE	: Higher Education.
HQ	: Head Quarters.
ICT	: Information and Communication Technology.
IP	: Intellectual Property.
IPMIS	: Integrated Project Management Information System (of CRC WS)
IT	: Information Technology.
KCTR	: Key Centre for Teaching and Research (Australia).
KM	: Knowledge Management.
Ltd.	: Limited.
MTIE	: Main Type of Information being Exchanged.
NBEET	: National Board of Employment Education and Training (Australia).
NHE	: National Hotline Engineers (of WTIA, chapter 6).
NIS	: National Innovation System.
NSW	: New South Wales (Australia).
NTA	: National Technology Advisers (of WTIA, chapter 6).

OECD	: Organisation for Economic Co-operation and Development.
PSR	: Public Sector Research (agency).
Pty.	: Proprietary (Australia).
R & D	: Research and Development.
SARDI	: South Australian Research and Development Institute.
SGI	: Silicon Graphics Institute.
SMART	: Save Money And Re-engineer with Technology (WTIA's Project).
SME	: Small and Medium Enterprise.
SPE	: Scientists, Politicians and Economists (society).
STM	: State Technology Managers (of WTIA, chapter 6).
TEN	: Techno Economic Network
TH	: Triple Helix.
TP	: Technical Panels (in CRC WS, chapter 6).
TN	: Technical Notes (in CRC WS, chapter 6).
TWI	: Technology Welding Institute (of England).
UoS	: University of Sydney (Australia).
UoW	: University of Wollongong (Australia).
US	: United States (of America).
USA	: University of South Australia.
UTS	: University of Technology Sydney (Australia).
VIDA	: Victorian Institute for Dryland Agriculture (Australia).
WTIA	: Welding Technology Institute of Australia.

ABSTRACT

Currently, in the process of creating innovation, some new forms of R & D collaboration are emerging, to fulfil the demands of the knowledge-based systems that must integrate industrial, scientific and commercial elements. These new forms are normally based on an integration of several participants from different institutions becoming involved in an inter-sectoral collaboration. This has been the subject of intensive study in most industrialized countries including Australia since 1980s. The Co-operative Research Centre is the Australian Government's answer to this new emerging phenomenon.

With the growing numbers of inter-sectoral collaborations especially aimed at innovation, the development of new theories in this field remains important and necessary. The current emerging theories of inter-sectoral collaboration are investigating how knowledge can be produced within such a complex environment while others are investigating how participants interact and communicate. So far, little investigation has been spent on the actual content of what is being transacted within such a complex inter sectoral collaborative R & D program, and what this (information) content and its transaction process may imply for the relationship among participants and finally how this may affect the performance of the entire collaboration.

This thesis attempts to present an analysis of the above issues, taking Co-operative Research Centres (CRC) in Australia as case studies.

From a theoretical perspective, the discussion in the thesis covers collaboration for innovation, information and the process of information transaction (including communication). The theoretical work also reviews the importance of the Internet in the process of information transaction in collaboration for innovation. The theoretical work pays special attention to the concepts of collaboration in the form of Mode-II Knowledge Production and the collaboration where the participants are specifically from University, Industry and Government agencies (the so-called 'Triple Helix'). The main objective of the theoretical work is to develop a better model to describe the importance of information and information systems in inter sectoral R & D collaboration. This new model is called the 'Newt' model.

To test the validity of the Newt model, fieldwork was conducted. The test was based on a qualitative analysis of data collected by using in depth interview with several important figures from each of the collaborating participants. Three CRCs were chosen as case studies. Since the model is intended to work in all CRCs, selection of the CRCs was done very carefully. The three CRCs reflect a very high degree of difference in terms of their type of research and are totally different research activities. They are the CRC for Welded Structures, (CRC WS) the CRC for Quality Wheat, (CRC QW) and the CRC for Advanced Computational System (ACSys CRC).

The thesis concludes that the CRC collaboration can be considered as a useful activity for information transaction among different participants. This activity appears to be triggered by a dominant participant with a particular type of information, and the entire process of information transaction in the CRC is based on the improvement of this particular type of information. In the process of information transaction, the role of each participant is based on the type of information being transacted. A participant who possesses this particular type of information is more dominant and more influential in the process of information transaction, resulting in an imbalance of information capacity. This information imbalance further creates a unique power relationship among these participants within the CRC collaboration. Under such circumstance, the Internet information system has a dual role, on the one hand it may enhance the process of information transaction, but on the other hand it may contribute to affect the power relationship between participants in the CRC collaboration, that is to create a master to slave relationship.

This finding has policy implications. It implies that there is a need to "label" each participant of CRC based on their information capacity both in terms of the quality and quantity of information that they hold. Before a CRC application can be approved and funded, a mapping of a likely dominant participant and those who are less likely to be dominant participants must be available. Based on such "information map" the government could support the CRC collaboration program more effectively.

CHAPTER 1. INTRODUCTION

1.1. BACKGROUND AND OBJECTIVES OF THE STUDY

This thesis investigates the importance of information systems in the innovation process in the R & D collaboration by taking three Australian Co-operative Research Centres as case studies. These are: CRC for Welded Structures (CRC WS), CRC for Advanced Computation Systems (ACSys CRC) and CRC for Quality Wheat (CRC QW). The thesis thus has three interrelating themes. These are: **innovation**, **collaboration** and the importance of **information systems**.

The importance of the production of innovation and how collaboration can be beneficial in creating innovation are factors which are first explored. Furthermore the thesis investigates the importance of information and information systems, especially the Internet, in relation to the production of innovation in the collaboration within the Australian Co-operative Research Centres (CRC). The aim of this thesis is to deliver a model which can explain the role of information systems in the process of innovation specifically under collaborative arrangement of CRCs. This thesis argues that a better understanding of the process of information transaction, as part of a CRC operation, may contribute to explaining the success (or failure) of a CRC's operation.

Overall the thesis has three objectives. Firstly, it analyzes the importance of the information system in collaboration between academia-industry-government partners within CRCs. Secondly, it analyzes the impact of information in determining the relationship among participants which in turn may contribute to the success of the CRC collaboration. Thirdly, it proposes a model to describe the role of the information system in CRCs and outlines some potential policy implications.

1.1.1. INNOVATION AND COLLABORATION

There are many literatures, which confirm the important role of innovation in economy growth, one of those is mentioned in Mercer and Stocker report as follows,

> "Innovation is a major determinant of the success of firms and economies. The development and commercialization of new products, processes, and services are key drivers of economic growth. Innovation depends on research and ready access and receptiveness to new technology and ideas. It propels productivity, spawns new industries and transforms existing industries. Economies which can effectively foster and commercialize innovations will grow faster and will generate more jobs and higher living standards". (Mercer and Stocker, 1998:p 7)

As CRC is the topic, then the thesis will concentrate more on R & D collaboration and technological innovations, in relation to this, Dogdson mentions that

> "collaboration, in the form of technology-based joint ventures, strategic alliances and multi partner R & D projects, is an increasingly important feature in the generation and diffusion of technological innovations" (Dodgson, 1998, p:2)

Moreover Teece reinforces this view by noting that

> "full commercial rewards of innovation can only be achieved when a firm has access to complementary assets (such as competitive manufacturing and distribution and marketing)" and "these can be linked to R & D by means of arm's length transactions, vertical integration, and collaboration (collaboration will allow these specialist skills to be accessed and can allow complex and tacit knowledge to be transferred and technology to be unbundled)". (cited by Dodgson 1996, p:64)

Meanwhile Powell et al (1996), states that

> "in organizations, which are complex and expanding and where the sources are widely dispersed, innovation will be found mostly in the network of learning firms rather than in individual firms……R & D intensities in such an industry are

> positively correlated with the number of alliances it exhibits". (cited by Child and Faulkner 1998, p:76)

Gibbons et al note the increasing trend to conduct collaborations by mentioning that

> "in the current highly competitive economy, to be able to commercialize knowledge means that firms often have to play a part in its production" (Gibbons et al 1994, p:50) and "they have to develop new types of links with universities, government laboratories and other firms". (Gibbons et al 1994, p:51)

The previous quotes conclude that technological collaboration is imperative for a successful technological innovation. In terms of the reasons for technological collaboration there are various arguments proposed by some scholars, such as Coombs et al who note that

> "the trends of increased collaboration are mainly as consequences of escalating R & D costs, the risks of radical technological change in a period of economic and financial instability, the growing pressure of competitiveness in increasingly globalized economy, and the importance of synergies, complementarities and interactions between a variety of scientific and technological fields". (Coombs et al 1996, p:2)

Other scholar Vonortas mentions the following reasons for collaboration in the form of inter-firm strategic alliances:

> "(a) to share the cost of investment, such as R & D; (b) to spread risk; (c) to access resources such as complementary technologies; (d) to accelerate the return on investment; (e) to create efficiencies through economies of scale, scope and/or rationalization; (f) to create otherwise unattainable investment options and (g) to co-opt competition". (Vonortas, 1998, p:181)

Another interesting reason for collaboration is to reduce the cost of in- house research as Gibbons et al further mention,

> "one reason why the maintenance of in-house research capability has become too costly is that firms are unsure about the particular knowledge they need; often it could have been produced almost anywhere". (Gibbons et al 1994, p:111)

Thus R & D collaboration is mostly driven by the increasing cost of R & D activity itself. Moreover other important reason is the highly uncertainty for conducting R & D activity as implication of possible radical changes in economy development.

In relation to the conduct of collaboration, Gibbons et al (1994) propose that collaboration, including R & D collaboration, as an activity of knowledge production, has evolved. In this context, Gibbons et al (1994) introduce the concept of Mode II Knowledge Production. In Mode II the problem solving is not carried out by following the codes of practice relevant to a particular discipline (the so-called Mode I) but by organizing the problem (and its solution) around a particular application. Gibbons et al note that

> "firms are more required to enter collaborative arrangement which have many of the characteristics of Mode II Knowledge Production". (Gibbons et al, 1994:p 51)

In relation to Gibbons Mode II Knowledge Production, it has been observed that, currently, the interaction between participants in the collaboration, especially from university, government agencies and industry, is becoming more complex. Tegart illustrates this complexity as follows,

> "the term 'Triple Helix' has been coined to describe the complexity of these interactions and Leydesdorff and Etzkowitz (1997) have used the term to describe what they call the *new paradigm of collaboration specifically between academia, industry and government agencies*. The term takes an analogy from the Double Helix used in molecular biology by Watson and Crick to describe the structure of the DNA molecule. The originators of the term namely Henry Etzkowitz ([working in the] US) and Loet Leydesdorff ([working in] The Netherlands) envisaged a spiral model of innovation to capture multiple reciprocal linkages at different stages of the capitalization of knowledge". (Tegart, 1996, p: 2, emphasis added)

The previous quote introduces the existence of a metaphor for the interaction between university, industry and government to produce innovation through the collaboration. This metaphor, called Triple Helix will be explained in detail in Chapter 2.

1.1.2. COLLABORATION AND INFORMATION

In relation to collaboration, Macdonald defines the three types of information most required for an organization as

> "(1) the type of information for doing something; this is normally already available in the organization; (2) the type of information for changing something; this normally must be gathered outside the organization; (3) the type of information to formulate the corporate strategy; this is required by the leadership and the management of the organization". (Macdonald, 1998, p: 260)

The relationship between collaboration for innovation and the role of information has been mentioned in some studies. In particular the relationship between information and innovation has also been covered in some literature. For example Maguire et al note that "information is important in innovation". (Maguire et al 1994, p:19) Macdonald reinforces this point by describing,

> "innovation as particularly dependent on the flow of information among firms….. most of the information required for innovations is gathered rather than created. Most important is that most of the information gathered for this innovation is available outside the organization". (Macdonald 1998, p: 246)

In addition Twiss notes that

> "innovations are increasingly dependent upon interactions between technologies, sometimes complex as in opto-electronics and other hybrid technologies". (Twiss 1992, p: xx)

From the previous statements it may be concluded that there is a logical need to conduct a collaboration with different participants in order to combine or "mix" more types of information to create innovation.

With the increasing complexity of the collaborative arrangements one can argue that the level of information will also become more complicated in that it will take a greater amount of channels at even more multi different levels and involve a continuing growth of different aspects of interactions. It will also become more difficult to find a common "language".

The role of the Internet in collaboration has been raised in several literatures such as for examples Teresko (2000); Porter (2001) and others. These literatures show that the Internet is accelerating the process of discovery in research by enabling rapid information transaction among colleagues around the world. The Internet also facilitates information transaction within a research community that is becoming increasingly fragmented by growing disciplinary specialization. Thus the Internet is not just merely speeding up the same kinds of interactions that would have occurred in other ways, but moreover it may contribute to the creation of a better focused research effort by providing a vital way of strengthening the links between performers and users of research.

The Internet thus plays roles through the way it is affecting research and the way researchers are relating to one another. As Gibbons et al argue

> "the future shape of knowledge production has to be seen in the context of the changing nature of the global economy and of ever new configurations of knowledge. In this, information technology systems clearly play a crucial role". (Gibbons et al, 1994: p 48)

An example of the previous statement is the fact that some collaborative arrangements have been applying the concept of the Internet based on-line collaboration. (Gilbert, 2000) In response to this some on-line collaboration softwares are also available. These softwares for example are used "to share data with customers, suppliers and subcontractors outside a company in order to make better use of external resources, meet customer expectations and quickly identify new product opportunities" (Gilbert, 2000, p:130). With the increasing usage of such on-line collaboration, many web based collaboration programs are also available (examples of Internet-based collaboration tools are iHarvest, NetDocuments, (Waltner, 2000, p:118)) and according to Waltner "these are mainly aimed at sharing, filing and indexing most documents available on the web attachments". (Waltner, 2000, p:117)

1.2. INTRODUCTION TO THE AUSTRALIAN CO-OPERATIVE RESEARCH CENTRE PROGRAM

In Australia the collaboration between university, industry and government agency is strongly supported by government. The government support is particularly aimed at structuring and formalizing the management of such collaboration, as Turpin et al mention the following,

> "Australia has a long and evolutionary history in the development of collaboration particularly between university-industry. Currently new forms of this collaboration are emerging to fulfil the demands for managers of the knowledge based systems that integrate industrial, scientific and commercial outcome. Among the most salient features of the knowledge based collaboration has been the increased role of government in stimulating and supporting such collaboration and the organizational *trend towards the creation of formalized and structured arrangements for managing collaboration*…. Government here, more than ever before, is concerned with directing national research efforts toward commercial outcomes and with building appropriate infrastructures for generating, transferring and utilizing marketable research outputs". (Turpin et al, 1996a:p 1, emphasis added)

Moreover the role of government funding remains important for university-industry collaboration as Turpin et al note,

> "the current research in this collaboration shows that such collaboration in Australia mostly has the following characteristics: (a) rely heavily on both informal (personal networks) and formal (organizational networks) linking mechanisms with a

> paramount importance of individual contact; (b) *are supported strongly by a continuum of government programs for stimulating and funding such alliances*; (c) are currently focused on providing a structural and organizational basis for university-industry collaboration in research, research training and delivery of enterprise-based training; (d) have evolved significantly, showing a trend toward formalized and structured arrangements for managing co-operation; (e) are leading to new organizational forms that rely on the integration of research, teaching/training and technical co-operation". (Turpin et al, 1996a, p 2-3, emphasis added)

Furthermore the annual report from DIST 1997 states that "in Australia a range of government programs have been introduced during the past decade with the intention of improving research collaboration between industry and universities". These four main programs included:

- "Key Centre for Training and Research (KCTR) program, introduced in 1985 and administered by the Australian Research Council (ARC). This program was conceived in order to enhance the teaching and research output of colleges in advanced education sectors. This program has been successful in more closely linking teaching programs to the need of the industry by bringing together different disciplinary strands into multi disciplinary teaching programs that directly address the training needs of particular industries."
- "Grants for Industrial Research and Development (GIRD) established under the Research and Development Act of 1986 administered by Department for Industry Technology and Regional Development. This program was set up to provide three kinds of funding supports: discretionary grants, national interest grants and generic technology grants. Each GIRD funded project has a commercial partner so the research conducted under these grants is directly relevant to industrial problem solving or innovative activities."
- "Co-operative Research Centres (CRC) set up in 1990 under the Department of Prime Minister and Cabinet[1]. This program aims to enhance the effectiveness of the overall Australian R & D effort by drawing together researchers from several institutions to create the concentrations of resources which are needed in many research fields to keep pace with the rapid scientific and technological progress which is occurring internationally. (Slatyer, 1993)"
- "Industry based, the Australian Postgraduate Research Awards (APRA) (Industry) introduced in 1990, and the ARC Collaborative Research Grants Program set up in 1991, both administered by the ARC (Australian Research Council). These programs were intended to support high quality research for social and economic benefit to

[1] When this quote was taken, the CRC was still under the Department of Prime Minister and Cabinet. However CRC has been under some changes. By November 2001, under the new Administrative Arrangements Orders of 26 November 2001, the CRC Program will now be located within the new Department of Education, Science and Training (DEST).

> Australia and to encourage research collaboration between higher education institutions and industry. "(Turpin et al, 1993a:p 23)

According to Turpin et al, "the GIRD program had some similarities to the CRC in the sense that the focus is to enhance research capacity and to link university research with industries, the difference lying in the scheme's strategic direction of research into pre-identified areas" (Turpin et al, 1993a: p 25), "while the ARC Collaborative Research Grants Program was intended to complement the CRC and GIRD schemes by providing support for collaborative research that was smaller scale than the CRCs, was shorter in time frame and did not require the formation of a formal research centre". (Turpin et al, 1993a: p 29)

Among the previous four programs, the CRC program is the largest and is the focus of this study. The program was started in 1990. In September 2001, there are 64 CRCs operating in six industry sectors. The mining and energy sector has 8, manufacturing technology has 12, agricultural and rural based manufacturing 12, environment 15, medical science and technology 10, and information and communication technology 7[2].

In relation to the role of collaboration for innovation the CRC program is an excellent example. As Mercer and Stocker have noted,

> "the CRC program is a government initiative to maximize innovation in Australia through new, collaborative methods in *research management*, technology transfer, and commercialization of research results. Recent reviews of the CRC program indicate that this program in general plays an important role in the Australian innovation system". (Mercer and Stocker, 1998:p 60, emphasis added)

[2] The lists of all CRCs as of November 2001 and June 2005 are given in Appendix 3 and Appendix 4 respectively.

From management perspective, the CRC model is thus the most suitable collaboration structure in Australia, especially in linking the university, industry and public sector research agencies. Therefore research in management of this CRC is both quite interesting and important.

1.3. RESEARCH QUESTIONS

Taking account the importance of innovation, collaborations, information exchange and new communication technologies, the research questions addressed in the thesis are as follows:

1. Is the collaboration between participants from government, academia and industry at CRC an activity to transact a particular type of information?
2. How does the pattern of information transaction within a CRC function in such a relationship between participants from government, academia and industry?
3. What is the role of the Internet information systems in the process of information transaction within the CRC collaboration?
4. What might the policy implications be for the government based on the characteristics observed as response to (1), (2), and (3) for better supporting the CRCs operation?

To answer the research questions an analytical model which describes the role of information systems in the CRC's operation will be developed. The starting point for the analysis is to investigate whether information is a key resource for collaboration in the CRC and whether the collaboration itself can be considered as an activity of information transaction. The thesis then proceeds by identifying the pattern of such transactions and analysing the role of information systems especially the Internet.

To answer the research questions, the research approach is divided into the following four steps:

<u>The first step</u> investigates whether there is a unique, particular type of information which triggers the CRC collaboration and discovers where this particular type of information comes from. The analysis is then extended to show how this particular type of information is transacted to the other participants and used by those participants within the CRC collaboration. To what extent this information is important and to what extent this particular type of information may drive the CRC collaboration is assessed. A discussion determines whether the relationship among participants in the collaboration is based on this particular type of information. The objective of this step is to investigate how the pattern of relationship among participants in the CRC collaboration is structured. This step concludes that a particular type of information determines a new kind of pattern of relationship among participants.

<u>The second step</u> investigates the process of information transaction among participants within the CRC collaboration. It assesses what the role of such a relationship is among participants in the process of information transaction in the collaboration. A major conclusion of this step is that the process of evolution of a CRC is due to the change of codification used in information transaction, which is dependent on the type of information.

The third step investigates the role of Internet information systems in the process of information transaction, especially to how they affect the relationship between participants in the CRC. This step notes that an Internet information system has a significant influence in shaping the pattern of relationships between participants in the CRC.

Besides theoretical approach such as developing the model, this work includes a field test by interviewing selected key figures from the CRC's under consideration. A detailed description of research methodology is given in chapter 5.

The fourth step is an assessment of the extent to which the model really works in each CRC. This is extended to an analysis about why it works or does not work. In this last part some limitations of the model are also explained. The analysis is followed by a description of some policy implications for better understanding of the CRC's operation. This last step concludes that even if the three case studies do not entirely resemble what the model has predicted, the model has still been able to describe the process of information transaction and the importance of the information system in the CRC operation.

1.4. ORGANIZATION OF THE THESIS

This section gives guidance on how to navigate the entire thesis. The thesis is divided into three parts as follows:

The first part of this thesis consists of chapters: 2, 3, 4, and 5. This part covers the literature review. It addresses the explanation of the theories used as a lead-in to the theoretical model. To this are added some examples from the literature. This is followed by an explanation of similar aspects in an Australian context, following which the new model is introduced to the reader.

In *Chapter 2*, the explanation of collaboration in conducting research for innovation is given. The discussion begins by introducing the importance of collaboration in the current world economy. The main consideration is the investigation of the relationship between collaboration and innovation and so in this chapter the advantages of collaboration to create innovation are addressed. In particular the discussion in Chapter 2 is extended to theories of 'Mode II' Knowledge Production. Finally a discussion is focused on the collaboration between government, industry and universities. In this context, the 'Triple Helix' metaphor is introduced.

In *Chapter 3*, a literature review of information for innovation in general is given. Moreover, this chapter explains how the information required for innovation can be exchanged in the collaborative partnership. Thus, this chapter also discusses some aspects of information transaction (including communication) in the innovation process. This chapter also presents some examples of the importance of particular types of information in a collaborative research partnership from the literature.

In *Chapter 4* the previous discussions about collaboration, innovation, and information are brought into a more specific context, which is the Australian context. The focus in this chapter gives an explanation of the government sponsored CRC program as an innovation mechanism. In this chapter the relationship between the CRC collaboration and the 'Mode

II' Knowledge Production and the 'Triple Helix' are explained. This chapter also discusses the Australian government's promoted information system that supports the business and industry sectors. This introduction to the information system is important, because the new developed model in chapter 5 includes the information system.

Finally in *Chapter 5* the theoretical model is introduced. This chapter explains the derivation of this model from existing theories and some ideas from the author. This chapter also explains its relationship with other already well-known and developed theories. Chapter 5 also describes several hypotheses to test the model. Armed with this model, the field survey is conducted in order to see whether the model really works in the CRC case studies. This part is fully covered in the next three Chapters 6,7, and 8.

The second part of the thesis presents the results of the fieldwork and subsequent analysis. The main content of this part tests the model developed in chapter 5 in the CRC case studies by comparing between: the CRC according to the model and the actual CRC. This comparison is made on the basis of qualitative analyses by using the data gathered from a field survey. In this part, issues such as: why the model works, or why it does not work in a particular case are also addressed. This second part consists of Chapters: 6, 7, and 8. Chapter 6 deals with CRC for Welded Structures, Chapters 7 and 8 deal with CRC for Quality Wheat Products and Processes, and CRC for Advanced Computational System respectively.

In *Chapter 6*, the case study investigates the CRC for Welded Structures (CRC WS), which is one of the most successful Australian CRCs and has completed the first round of its operation[3]. The main objective of this chapter is to test the model developed in chapter 5 on this particular CRC. This is conducted by a qualitative analysis on the basis of data collected from a field survey. In this chapter, some new important and interesting discussions are addressed.

In parallel to the previous chapter, *Chapter 7* describes similar issues. In this chapter the CRC for Quality Wheat is taken as the case study. This CRC is also one of the successful Australian CRCs.

Chapter 8 parallels to previous two chapters, and this time the CRC for Advanced Computational Systems is taken into consideration. This CRC is dealing with computer and information technologies.

The third part of the thesis presents a comparative analysis of the CRC case studies. This is followed by considering some possible policy implications that may follow from the previous discussions. This last part consists of chapters 9 and 10.

Chapter 9 takes a comprehensive analysis of the previous three CRCs under consideration. The model is assessed especially in its capability and suitability to the CRC case study.

[3] When this report was written in 2001 the CRC WS has completed 1st round. The meaning of first-round: is 7 (seven) years of CRC operation. See chapter 4 for more detailed explanation of CRC.

In *Chapter 10*, general conclusions are given. This chapter explains the limitations and restrictions of the developed model. This chapter concludes that features of two CRCs case studies (CRC QW and CRC WS) seem to closely resemble the model, however the same does not apply to the other CRC (ACSys CRC). Finally there follows a discussion of six potential policy implications from the previous discussions.

1.5. CONCLUSIONS

This chapter has described the background of the thesis including its main objective and the importance of the issues it covers. Currently, with increasing competition and a highly dynamic environment it is nearly impossible to become innovative without having collaboration. The thesis focuses on the specific collaboration between academia-government and industry in Australia, under the CRC program.

The main goal of the thesis is to study the importance of information systems in a collaborative partnership for innovation between industry, government and universities under the CRC program. The research method used is to conduct both theoretical approach and fieldwork in order to analyze the process of information transaction and the role of the Internet in this process of information transaction and how it may contribute to the success (or failure) of a CRC collaboration. The thesis will develop a model, which is intended to contribute to a better understanding of the role of information systems in the process of information transaction in CRCs, which may help in explaining the success (or possibly failure) of a CRC collaboration.

Using this model should enable us to observe the role of another aspect of the CRC collaboration towards innovation. This is the information aspect and given the increasing usage of information systems and technology, this way of observing the CRC collaboration may offer a closer explanation to the actual operation of a CRC than existing models of R & D collaboration.

CHAPTER 2. INNOVATION, COLLABORATION AND "MODE II" KNOWLEDGE PRODUCTION

This chapter briefly reviews the literatures on collaboration and innovation. It explains the benefits of having a collaborative partnership and also the so-called 'Mode II' Knowledge Production. The difference between Mode II and Mode-I Knowledge Production will also be outlined. The main objectives of this chapter are to introduce the role of collaborative partnerships for innovation and to introduce some aspects of having participants from different types of organization in such collaborations. This chapter also introduces the 'Triple Helix' concept of collaboration. The Triple Helix is useful to analyze collaboration conducted by participants from university, government and industries, and it is closely related to the realization of Mode II Knowledge Production.

Innovation is the other issue discussed in this chapter. How this can be produced and how collaboration can be beneficial in creating innovation are two factors of interest. This chapter functions as a lead-in to subsequent chapters about Australian collaborative research arrangements in the form of the Co-operative Research Centre.

The organization of this chapter is as follows. Section 2.1 discusses the relationship between collaborative research partnership and innovation. In section 2.2 a discussion about Mode II Knowledge Production and its comparison with Mode 1 is presented. In section 2.3 the Triple Helix is explained. Finally some conclusions are given in section 2.4.

2.1. INNOVATION AND COLLABORATION

This section discusses theories on collaboration followed by the discussion for the role of collaboration for innovation. This section argues that collaboration fuels innovation and innovation is strongly dependent on management factors. Meanwhile collaboration is a complex and multi facets phenomenon. This complexity is caused by several factors as a reflection of multi interest from different participants. In spite of its complexity, collaboration has been considered as a way to produce innovation therefore managing collaboration is important in creating innovation.

2.1.1. INNOVATION

This section deals with some aspects of innovation from management perspective. This section argues that innovation and management are strongly related to each other. First of all for the definition of innovation, Maguire et al describe that,

> "the word innovation derives from the Latin *innovare,* meaning to renew or alter. The Oxford English Dictionary also offers a meaning of innovation, which it describes as 'in commercial usage' namely 'the action of introducing of a new product into the market; a product newly brought on to the market'. This meaning is dominant and is the popular understanding today, but it is useful to widen this definition to cover developments other than new products. Thus innovation is also a change in the processes so that old products are made in new ways. The novelties brought about by innovation may be in services or in the systems of management and marketing by which products and services are brought into being and distributed". (Maguire et al 1994, p: 2)

There is a difference between technical and social innovation. In this section discussion is limited to technical innovation, something which will be discussed further in the new model introduced in chapter 5. A useful definition for technical innovation is given as follows:

> "A technical innovation is a complex activity which proceeds from the conception of a new idea (as a mean of solving a problem) to a solution of the problem, and then to the actual utilization of the new item of economic or social value. Innovation should be distinguished from scientific discovery, which involves the observation of a previously unknown or unobserved phenomenon or the acquisition of new knowledge; although relevant discoveries may be incorporated into the innovation. Innovation should also be distinguished from invention, which is the creation of a novel product or process, or a concept or means of satisfying a need. The invention however may provide the initial concept leading to the innovation. Finally, innovation must be differentiated from diffusion of technology, which one author has defined as the evolutionary process of replacement of an old technology by an newer one for accomplishing similar objectives but which we have broadened to include the extension, improvement and wider use of existing technology. The period of innovation is assumed to extend over a bounded interval of time, extending from the first conception of the idea for the innovation to the first realization, when the first commercially successful embodiment of the innovation entered the marketplace".
>
> [Taken from Battelle Colombus Laboratories, *Interaction of Science and Technology in the Innovative Process: Some Case Studies*, final Report to the National Science Foundation, Battelle Colombus Laboratories, Ohio, March 1973. See Lundstedt and Colglazier 1982, p: xxi]

The role of environment which can provide a conducive situation for innovation and the role of management in providing such situation are evident, as illustrated by Maguire et al, "the following three propositions in the study of innovation as phenomenon Maguire et al, (1994, p:267, emphasis added):

- "Proposition about managing innovation. (1) Innovation is centrally *a matter of organization*, rather than technology; (2) invisible assets are important for realizing the innovation's benefit; (3) managerial style is a more important determinant of the effects of technological innovations on an organization than the technology employed".
- "Proposition about the inputs to innovation. (1) Progress from invention to application is not linear; (2) neither science (or knowledge) push nor market pull can be categorized as the sine qua non of successful innovation".
- "Propositions about the environment for innovation. (1) The more complex the system into which an innovation has to move, the more resistance it will meet; (2) opinions differ on whether innovation is more likely to be achieved by strategy or serendipity in small or large organizations and in good or bad economic times".

Moreover the role of management in providing innovation is by managing the possible sources of innovation. This has been deeply investigated by several scholars, one of them is Von Hippel who notes that

> "the sources of innovation vary greatly. In some fields innovations users develop most innovations. In others, suppliers of innovation related components and materials are the typical sources of innovation. In other fields conventional wisdom holds and product manufacturers are indeed the typical innovators". (von Hippel 1988, p: 3)

Moreover, von Hippel notes that

> "the variation of sources of innovation is greatly caused by variations of potential innovators to expect profit from innovation work. Von Hippel defines that the management of the distributed innovation process is through two ways: (1) by understanding how expected innovation profits are distributed we may be able to predict the likely source of innovation; (2) by changing the distribution of such profit expectation we may be able to shift the likely source of innovation" (Von Hippel 1988, p: 6)

The two previous quotes from von Hippel stress the role of management in producing innovation. Other scholars that provide the crucial role of management in innovation process are Brown and Karagozoglu who add that

> "the successful implementation of innovative ideas in organization depends on four crucial factors: *the organizational structure*, the *quality of information flow*, *the relevant manpower flows* and the *specification of key roles for innovative action*" (cited from Maguire et al 1994, p: 55, emphasis added).

The four items (given in italics) in the previous quote are normally management aspects, these are under control of management and are part of the management activities. Other scholar, Peter F. Drucker (1985) (see Maguire et al 1994, p: 4) characterizes innovation as, " the art that endows resources with a new capacity to create wealth" and to this he adds the corollary, "equally whatever changes the wealth producing potential of already existing resources constitutes innovation". Maguire et al also further note that

> "innovation is important to individual firm for much the same reason it is important to a nation. Moreover, they also note that innovation is centrally *an organizational and managerial issue* because innovations are produced within organizations that transform "knowledge". (Maguire et al 1994, p:12, emphasis added)

The previous quote strengthens the importance of management in production of innovation. Management itself can be a product of innovation, as Freeman and Perez (1988) (cited from Niosi 1996, p:99, emphasis added),

> "classify innovations into four categories of increased complexity and systemic effects. These are: (1) radical innovation, (2) incremental innovation, (3) changes of technology system and (4) changes in techno-economic paradigm (*changes include many clusters of a technology system together with organizational and managerial innovations*)".

As management is important to innovation, then there is a need to construct a management model that may support the process for the creation of innovation. Moreover, the management by involving several participants, such as in collaboration, are considered to be more complex and thus the innovation production would be more complicated. The next section will discuss the collaboration as lead-in to the discussion about collaboration for innovation.

2.1.2. COLLABORATION

The main objective of this section is to present reasons for collaboration, structures of collaboration and success factors of the collaboration. In fact, although collaboration occurs in many different forms, and may reflect different motives, a number of generalized assumptions underpin them. (Dodgson, 1998:p 3)

- "First is the belief that collaboration can lead to positive sum gains in internal activities. That is partners can together obtain mutual benefits which they could not achieve independently. Such benefits may include: (1) An increased scale and scope of activities: the outcomes of collaboration may be applicable to all partners' markets, and thus may expand individual firm's customer bases. Synergies between firms' different technological competences may produce better, more widely applicable products; (2) shared costs and risks: collaboration can share often very high costs and therefore risks, of innovation (although it also shares future income streams); (3) improved ability to deal with complexity: innovation is increasingly complicated, and closer strategic and technological integration between firms is a means for dealing with the complexity of multiple sources and forms of technology".

- "A second assumption regarding collaboration concerns the way it is believed to assist with environmental uncertainty. Increasingly sophisticated and demanding customers, growing competition in and internationalization of markets, and rapidly changing and disruptive technologies place pressure on firms to exist with, and attempt to control, these uncertainties confronting them. This is believed to be achieved more easily in collaboration than in isolation".
- "A third set of assumption underlying collaboration is one that considers it offers flexibility and efficiencies compared to its alternatives. For example collaboration may be an alternative to direct foreign investment and mergers and acquisitions which are much less easily amended once entered into. Collaboration can allow firms to keep a watching brief on external technological developments without having to invest heavily. Large firm/small firm interaction might be facilitated such that the resource advantages of the former are linked with the behavioural or creative advantages of the latter whilst maintaining their independence. Much technological knowledge is tacit – that is difficult to codify in the form of blue prints, etc.- and firm specific. (Pavitt, 1988) It is therefore difficult to transfer easily or quickly. Collaboration potentially provides mechanism whereby close linkages among different organizations allow sympathetic systems, procedures and vocabulary to develop which may encourage the effective transfer of technology".

From the previous quote the three keywords for reasons of collaboration can be derived, these are <u>flexibility</u>, <u>positive sum-gains for internal activity</u> and <u>dealing with uncertainty</u>. These three are related to management and when there are many participants a collaboration (such as in Cooperative Research Centre, CRC) the need to have a good management in dealing with those keywords is important. Some more important aspects of collaboration from management perspective are proposed by Dodgson as follows:

> "(1). Changing system of production. Firms are forced to collaborate because of the increasingly high level of uncertainty due to historical loss of control over markets and extensive industrial restructuring".
>
> "(2). Technology and Innovation. This group of theories highlights the role of technology within the industrial reorganization and restructuring. Emphasis lies with the scale, scope and cost of contemporary technologies, and the uncertainties facing the development and market diffusion of pervasive technologies (particularly information and communication technology)".
>
> "(3). Economic and competitive relations. The structural nature of markets and industries profoundly affects the extent of inter-firm links. Collaboration needs to be viewed in a competitive power perspective. Collaboration is a continuation of competition and should be seen as a transitional stage in firm positioning".

> "(4) Organizational learning. Collaboration in the form of joint ventures is considered as a vehicle by which knowledge is transferred and by which firms learn from one another. The primary ascribed motive for learning through inter-firm links is to deal with technological and market uncertainty. The collaboration is not a static but a dynamic process. It is necessary to account the adaptability and change in inter-firm links". (Dodgson, 1996, p: 58-67)

In addition to Dodgson (1996), Child and Faulkner (1998, p: 74-81) mention in detail that each partner in doing the collaboration will consider the following aspects from their internal perspective:

1. <u>"Resources dependencies.</u> The need to get access to particular skills from another company. This skill can be anything ranging from technical know how to management skill and market skills.
2. <u>Learning.</u> Knowledge creation occurs in the context of community, on that is fluid and evolving rather that tightly bound or static. The canonical formal organization with its bureaucratic rigidities is a poor vehicle for learning.
3. <u>Risk limitation.</u> A company with only moderate financial resources may deal with either an opportunity or a defensive challenge, by seeking an alliance with a partner who can help spread the financial risk.
4. <u>Speed to market.</u> Especially in the economic world of the 1990s, first mover advantages are becoming important, and often the conclusions of an alliance between a technologically strong company with new products and a company with a strong market access is the only way to take advantage of an opportunity in time.
5. <u>Cost minimization.</u> Companies will form alliances only if the transaction costs involved in so doing are perceived to be lower than those for the other options.
6. <u>Current poor performance.</u> a prime motivator for becoming involved in co-operative activity, particularly in innovative R & D, is existing poor performance. If performance is currently poor, there is little to be lost by finding something different to do in order to improve results".

All the six mentioned perspectives deal with management. It is interesting that collaboration is considered as a way to deal with complexity in marketing (management) in the nineties. Other scholars, Gibbons et al share the same perspective as follows,

> "commercialization is more complex than envisaged in the traditional linear mode, where science leads to technology and technology satisfies market needs. Technology is not a commodity, available "off the shelf"; nor can it be guaranteed through technology transfer or intellectual property agreements alone. More often, it needs to be developed to meet the circumstances of a specific firm. Gibbons et al note that in order to commercialize knowledge, firms have to look for new types of links with

> universities and government laboratories as well as with other firms". (Gibbons et al 1994, p: 46)

The other perspective calls collaboration as a way to improve performance in R & D activity. These two perspectives (the need to improve R & D performance and marketing management) are the most relevant with Cooperative Research Centre in Australia (which will be explained in more detail in chapter 4).

As a CRC has Public Sector Research (PSR) as its main component, it is useful to quote the reasons for conducting a collaboration from the literature. Scholars Fritsch and Schwirten (1999, p:69) add the following driving force for collaboration for the PSR:

1. "Gaining relevant practical inspiration for their own research projects and the correspondence of different research agendas (technical information)".
2. "Financial motives (not a strong driving force)".
3. "To gain inspiration for further research activities (this is the primary motive for the PSR to maintain co-operation with private sectors)".

The last driving force for collaboration of PSR is understandable, especially in CRC case where a strong linkage between industry and public sector research agencies are highly recommended by the government (more on this topic will be outlined in Chapter 4).

Leveque et al (1996, p:186) define that "there are two organizational forms of R & D co-operation which are grouped in the following two axes:

> "*The vertical axis*. This axis provides the conceptualization of inter-firm co-operation. For the transaction cost theory, co-operation occurs when neither market nor hierarchies are completely satisfactory. Collaboration is viewed as an efficient governance structure when transactions are surrounded by uncertainties and specifity of assets".
> "*The horizontal/temporary axis*: This axis refers to the temporal variations in the forms of technological co-operation. The changes in R & D co-operation are the result of technological factors and/or firm strategies. According to this concept, the R & D

> co-operation is expected to decrease over time, as technological uncertainties decrease and firms operate their integration strategies".

The previous quotes are relevant to CRC case study for the CRC is an R & D activity. The R & D collaboration is strongly dependent on two main factors these are the uncertainty and technology factors. Both factors play an important role in CRC case study since in all CRCs are mainly dealing with technology development (especially for the benefit of industry, more on this topic is outlined in chapter 4). In term of R & D activity, the collaboration remains a management issue as Leveque et al comment in the following quotes,

> "the collaboration between firms takes different shapes in term of organizational structures because the collaboration has the dynamic behaviour from within. This dynamic behaviour is based on type or modes of collaboration, which can be categorized into three modes. These are the exploratory, the exploitative and the imitation". (Leveque et al, 1996,p:187)

Leveque et al also note that "the viability of the firms requires that the three modes be integrated within it (Leveque et al, 1996, p:189). Leveque et al argue that

> "there is an interdependency between the three modes which is fundamentally based on dynamics. The exploratory R & D opens the gate to exploitative R & D which itself renders possible imitative R & D. In a long period, there is no continuous exploitative R & D without exploratory R & D within the firm nor imitative R & D without exploitative R & D within the firm" (Leveque et al, 1996 p:190).

Furthermore Leveque et al note that, "exploitative R & D is exhausted when it does not enable the firm to differentiate". (Leveque et al, 1996 p:190) Moreover Leveque et al (1996, p:190) have defined:

- "To each firm corresponds a specific intensity and nature of industrial R & D.
- The industrial R & D evolves over time according to the dynamics of the differentiated oligopoly".

The above two aspects will have two implications regarding co-operation (Leveque et al, 1996, p:190):

- "The pattern of co-operation reflects the pattern of internal R & D.
- The evolution of R & D co-operation follows the dynamic of the differentiated oligopoly".

The above three modes (exploratory, exploitative and imitative) are not static but a dynamic process which is dependent on the management setting of the involving participants. The following quotes illustrates this point,

> "the characteristics of co-operation in each R & D mode as follows. Exploitative R & D is the production side of R & D. The exploitative R & D co-operation has the following characteristics: (1) number of agreements: few, as well as numbers of partners; (2) complementary of partners: product line/market; (3) technology exchanged: less tacit and embodied in artefacts/text; (4) human resources involved: engineers; (5) assets involved: specific and rigid; (6) linkages with universities: few and weaker; (7) specific forms used: customers-suppliers technology exchange agreements; (8) common forms used: R & D contracts, joint R & D, joint ventures, licensing". (Leveque et al ,1996 p:194)

Leveque et al furthermore note the difference between exploratory and exploitative R & D as follows,

> "collaboration in exploitative R & D is supposed to occur when partners have or are trying to develop similar competencies, at least when methods are concerned, so that economies of scale can act; but have complementary product lines and markets, so that economies of scopes can be better exploited and lead times shortened. Moreover as the task of exploitative R & D is to generate innovation propositions that will involve the whole company, strong linkages between R & D and production and marketing activities of the firm are needed. The extreme importance of information, coordination and control channels demands that co-operation, when concerning the process of innovation itself, be very close with internal organization, or, when the activity in question can be detached from the process of innovation, that the interface between organizations involved be standardized and co-operation be similar to market transaction". (Leveque et al, 1996, p:190)

Moreover Leveque et al mention that

> "the task for exploratory R & D is to prepare new irreversible investments. As such, the function of collaboration is to access new knowledge and internalize and specify what seems promising. The main source of performance in exploratory R & D is its learning capacity, and co-operation facilitates this task through the enhanced learning implied by the greater involvement of the partners that permits easier access to the partners' competencies and skills. The exploratory R & D co-operation has the following characteristics: (1) number of agreements: many, as well as numbers of partners; (2) complementary of partners: technological (including method); (3) technology exchanged: more tacit and embodied in people; (4) human resources involved: scientists. Assets involved: generic and flexible; (5) linkages with universities: many and stronger; (6) specific forms used: research grants minority equity; (7) common forms used: R & D contracts, joint R & D, joint ventures, licensing". (Leveque et al, 1996, p:191-192)

The previous two quotes stress the need to have a collaboration with university as an important factor in R & D works. Thus the role of university as partner in production, creation and internalization of knowledge is important. It is evident that if firm has own competence to innovate then the need to collaborate decreases and imitative mode of R & D will be used as given by the following quote,

> "if the firm adopts an imitative R & D strategy, it will be rarely to co-operate, because the internal availability of the resources needed by innovation and the absence of technical risk reduce the incentive to co-operate". (Leveque et al, 1996, p:193)

The existence of the three modes and the fact that these modes can be selected interchangebly by firms, reveals the role of management in R & D collaboration. It is a matter of management that changes and adapts firm' strategies.

Meanwhile the success or failure of collaboration is dependent on several factors. Mark Dodgson notes that *trust* is an important factor for a successful collaboration, as given in the following quote:

> "the quality of relationship between partner firm has obvious implications for outcomes. Meanwhile, the literature suggests that one of the factors, which determines this, is trust. There are three trusts: (1) competence trust concerns the

> expectation of a (trading) partner performing his/her role competently, (2) contractual trust: each partner adheres to agreements, and keep promises and (3) goodwill trust: refers to mutual expectations of open commitment to each other." (Dodgson 1996, p:67)

In relation to trust, management remains such an important factor as Dodgson notes that

> "a number of reasons can be suggested to explain why high trust facilitates effective inter-firm links, both horizontal and vertical. The first relates to the sort of knowledge being transferred, which is often tacit, uncodified, firm specific and commercially sensitive. It is therefore not readily transferable, requiring dense and continuing communication paths. A second reason relates to time scale of successful inter-firm links. Trust facilitates continuing relationships between firms. Continuity is valuable because the objective of inter-firm links may change over time, in line, for example, with changing or new market and technological opportunities. A third reason for high trust in collaboration reflects the high management cost of such linkages. Selecting a suitable partner and building the dense communications paths through which tacit and uncodified information can be transferred has considerable management costs, both real and opportunity". (Dodgson 1996, p:69)

The previous quote stresses that high management cost to maintain trust implies that each partner in collaboration must be able to conduct good and reliable management procedures especially in dealing with transfer of information.

There are cases where collaboration has failed and in some other cases collaboration has proven to be a successful activity. The following quotes explain major causes of failure in collaboration as well as successes of collaboration. Coles et al identify major causes of failed collaboration which reveal that failures of collaboration are management matters,:

1. "Asymmetries in: information access and provision, control over intellectual property, resource allocation, balance of power".
2. "Partner problems: inflexibility of partner, delivery delay or even delivery failure, personnel changes, differing priorities between partners".
3. "National differences in: technical standards, expectations of performance". (Coles et al, 1997, p:428)

Koschatzky and Sternberg mention result of study from large scale survey of collaborative activity as follows,

> "it has been proven, that collaboration, has been a key-success for a huge number of manufacturing sectors in Europe. A recent large-scale survey about R & D co-operation in innovation conducted in ERIS (European Regional Innovation Service) has proven this fact. Data reveals that manufacturing firms with an intensive network integration (local or not) are more successful than those without it. (Koschatzky and Sternberg, 2000, p:489)

Moreover, Koschatzky and Sternberg note that

> "firms which access external information and knowledge by their own networking activity are economically more successful than firms which do not co-operate with other partners". (Koschatzky and Sternberg, 2000, p:489)

Successful collaboration obviously brings many benefits for the participant. Hence, an R & D collaboration such as CRC model should be able to deliver benefit to its participants. However a successful collaboration need some requirements, which mainly deals with management. The next section discusses the innovation in more detail and the discussion of collaboration for innovation is given in section 2.1.3.

2.1.3 COLLABORATION FOR INNOVATION.

This section discusses the role of collaboration for innovation. The main objective of this section is to argue that collaboration has an important role in producing innovation.

In fact, the role of collaboration for providing innovation is evident. "Firms when they collaborate will possess some potentialities to create new innovation" (Coombs, et.al. 1996, p:26). While, Mark Dodgson mentions, a strong reason to collaborate is the need to generate and diffuse technological innovation,

> "In most cases, collaboration in the form of, e.g: technology based joint ventures, strategic alliances and multi partner R & D projects, are an increasingly important feature in *the generation and diffusion of technological innovation*". (Dodgson, 1998: p 2, emphasis added)

Another scholar, Ahuja mentions that,

> "In relation to innovation, collaboration facilitates bringing together complementary skills from different firms. (Richardson, 1972; Arora and Gambardella, 1990) Technology often demands the simultaneous use of different sets of skills and knowledge bases in the innovation process. (Arora and Gambardella, 1990; Powell, Koput, and Smith-Doerr, 1996) Developing multiple, broad competencies or maintaining them in the face of rapid technological changes, however, is difficult for firms. (Mitchell and Singh, 1996). Under such circumstances, collaboration can enable firms to enjoy economies of specialization, without prior investment entailed by internal development. By tapping into developed competencies of other firms, firms can enhance their own knowledge base and thereby improve their innovation performance" (Ahuja, 2000, p:428)

Ahuja adds that

> "Prior research has also shown a *positive impact of inter firm collaboration on innovation output*. In a study of biotechnology start-ups, Shan, Walker, and Kogut (1994) have found that the greater the number of collaborative linkages formed by a start-up, was *positively related to its innovation output*". (Ahuja, 2000,p:427, emphasis added)

Other scholars, Laredo and Mustar describe collaboration specific in R & D program as follows,

> "The collaboration between numerous actors will be a key feature for both innovation processes and of technology programs, because: (1) Science is no longer information and requires direct connections between scientist and engineers (2) technology is non rival in consumption (3) collective anticipation is crucial to their identification and development.". (Laredo and Mustar, 1996, p:149)

Coles et al also stress the relationship between collaboration and innovation by noting that,

> "another reason is because a firm is to make profit and collaboration (for innovation) can be viewed as part of the search and selection, designed to increase profitability. The essence of this kind of innovation collaboration between firms is in a symbiotic relationship. New technology is developed which could not have been created independently because of resource constraints". (Coles et al, 1997, p: 429)

The above description is necessary, because CRC case study (introduced in chapter 4) is an R & D collaboration. The previous quote strengthens that collaboration certainly enhances innovation, however since collaboration for innovation requires to bringing complementary assets from participants (because of resource constraints), this may require further consideration especially from management perspective: that is how to manage the complementary assets from participant in order to produce innovation. This management is supposed to be more complex, when the process to create innovation is more often originates from collaboration (see previous quotes from Ahuja and Dodgson). In relation to this, Jorge Niosi introduces the concept of co-operative innovation as follows,

> "The emerging theory of cooperative innovation is based on assumption that technology is a quasi public good and that learning process is mostly localised. Under new conditions of economic and technological turbulence, the shortening of life cycles of products and processes and the increasing numbers of competitor, companies prefer to collaborate with some rivals, in order to compete with others". (Niosi, 1996, p:102)

The co-operative innovation strengthens the argument that collaboration is getting more preferable not only to innovate but also to compete. This concept is further augmented by Mark Dodgson as follows, There are two structures of collaboration**:**

> "(1). Vertical collaborations, which occur throughout the chain of production for particular products, as for example, the provision of raw material, through the manufacture and assembly of parts, components and systems, to their distribution and servicing. Vertical, user/supplier links are known to play a centrally important role in the innovation process".
>
> "(2). Horizontal collaboration which occurs between partners at the same level in the production process. Horizontal links are also argued to assist the innovation process, although firms appear comparatively more reticent to form such collaborations as they may more often end in dispute over ownership of their outcomes, such as in intellectual property rights, or *in the direct competition between collaborating firms*". Dodgson (1998:p 2, emphasis added)

The CRC can be viewed as part of co-operative innovation activity, because there is a need to collaborate in order to innovate given a high level of uncertainty in technology development which reduces the product and process life cycles. This fact can be compared to Laredo and Mustar comments on co-operative research as follows

> ," the organizational forms that were developed to carry out co-operative research, and derive maximum benefit from it, involved the building of links between a variety of heterogeneous actors, including university laboratories, technical research centres, financial organizations, users, public authorities etc. These are organized relations that mobilize various types of intermediaries and coordinated mechanisms, which did not limit themselves to research, but embraced all elements and actors of the innovation process". (Laredo and Mustar, 1996, p:155)

Laredo and Mustar (1996) call these arrangements as "Techno-Economic Networks" (TEN) and it has the following characteristic;

> "it is a coordinated set of heterogeneous actors-laboratories, technical research centres, financial organizations, users, public authorities- which participate collectively in the development and diffusions of innovations and which organize, via numerous interactions the relationships between research and the market place; a network is not just defined by the actors that make it up. A whole set of intermediaries circulates between them which give material contents to the links uniting the actors: they can be written documents (scientific articles, reports etc), incorporated skills (engineers moving between companies), money (subsidies and grants), and support materials (samples etc), technical artefacts (prototypes etc.)". (Laredo and Mustar, 1996, p:155)

Such complex arrangement as TEN would require a well-coordinated management in order to make it operate successfully. The CRC case study (will be explained later in ch.4) is not quite similar to TEN but it resembles some similarities. The concept of TEN reveals that a collaboration for innovation may have to deal with a complex management problem.

2.2. "MODE II" KNOWLEDGE PRODUCTION

This section describes the so-called Mode-II Knowledge Production. The Mode-II Knowledge Production will be used to develop the model introduced in chapter 5 therefore an introduction to this theory is necessary. Gibbons et al propose Mode-II in the following terms:

> "the so-called Mode II Knowledge Production is created in broader trans-disciplinary social and economic contexts. Thus, in contrast to Mode I, which is based on disciplinary, primary cognitive context (or traditional context) Mode II has a broader context. Organizations have flat, task focused structures that allow flexible patterns of collaboration between research and development staff who are often not located in the same physical institution. Accountability, quality control and the validation of new knowledge is accomplished with reference to a broadly based group of stakeholders.". (Gibbons et al, 1994, p:1)

The main difference between Mode I and Mode II is summarized in Table 2.1 (see page 37). From the given table it can be concluded that according to the Mode II concept, the collaborative partnership is seen from the following perspective: (1) the locus for producing knowledge is no longer limited to universities but also non university-institutes, companies, or private research centres, government owned labs, and think-tanks in their interaction; (2) the existence of links between the actors from different locus of knowledge production by informally, electronically or other means; (3) the simultaneous differentiation of these sites, of fields and areas of study into finer and finer specialities. Gibbons et al further elaborate the difference between Mode-I and Mode-II by noting that,

> "in general Mode II is more complex. It is shaped by a more diverse set of intellectual and social demands than was the case in many applied sciences while it may give rise to genuine basic research. In Mode II, the results and other topics are communicated to those who have participated in the course of participation and so in a sense, the difference of the results is initially accomplished in the process of their production research". (Gibbons et al, 1994:p 5).

Mode-II Knowledge Production takes into account the role of many partners in the production of knowledge as Gibbons et al note,

> "operating in Mode II allows participants to be more reflexive. This is because the issue on which the research is based cannot be answered in scientific and technical terms alone. Research towards the resolution of these types of problems has to incorporate options for the resolutions and these are bound to touch the values and preferences of different individuals and groups that have been seen as traditionally outside scientific and technological systems. They can now become active agents in the definition and solution of problems". (Gibbons et al, 1994:p 7)

Mode-II Knowledge Production is required since there has been a growth in problem oriented research, and as Gibbons et al note, "Alongside the growing prominence of research an equally important shift has taken place in its character". (Gibbons et al, 1994:p 78)

Further Gibbons et al elaborate that research activity is getting less and less caused by curiosity driven of scientists but more caused by many "stakeholders",

> …"less and less it is curiosity driven and funded out of general budgets, which higher education is free to spend as it likes; more and more it is in the form of specific programs funded by external agencies for defined purposes. The shift is also reflected in a changing view of university research. The emphasis has moved away from free enquiry to problem solving perhaps with too little regard being paid to problem definition and articulation. It is also reflected in a changing economy of research; projects are constrained by specification of increasingly expensive equipment and by specialized skills of researchers. It is hard to obtain support for research which is not conscious, leading to rationing of equipment and personnel. The result is a squeeze of both intellectual and actual research possibilities entailing their concentration only in certain locations". (Gibbons et al, 1994, p:78)

The relationship between the need to collaborate and Mode-II Knowledge Production is explained by Gibbons et al by noting that,

> "increasingly marketability, the growing demand for knowledge and the spread of Mode II are linked through dynamic competition. Intensifying competition still provides the imperative for innovation but increasingly this involves the generation of new knowledge. As noted, to meet their requirements, firms need to participate in this process and are entering into new collaborative arrangements, which have many

> of the characteristics of Mode II. These linkages highlight the role of new knowledge configurations in the innovation process, and these configurations cross not only disciplinary but also institutional boundaries". (Gibbons et al, 1994:p 51)

This phenomenon makes the collaboration more attractive to many actors in the knowledge production system, especially those who are working towards innovation and is making Mode II more suitable to deal with all complexities in such collaborative work towards innovation.

The next section will deal with the Triple Helix, a metaphor that like Mode II specifically describes the collaboration between academia-university and the public sector research agencies.

Table 2.1. Mode I and Mode II Knowledge Production
Source: Cohen et al (2001, p:148)

	Mode I	Mode II
Context	Problems are situated and examined in an academic context in relation to the cognitive and social norms of basic research. Research is driven by the interests of a specific academic community, with no specified practical outcome.	Research is intended to be useful to industry, government, or society at large and is organized around a specific issue or problem. Knowledge is produced in negotiation with diverse stakeholders and reflects their interests.
Discipline Base	Knowledge is developed consistent with the frames of reference, cognition, and social norms of specific academic disciplines. Distinction between theory and application.	Knowledge is trans-disciplinary, integrating different skills, cognition and social norms of various stakeholders and establishing consensus. Dynamic flow between theory and application.
Social Organization	Knowledge production is deeply institutionalised and typically based in universities and colleges with limited multi-agency collaborators. Research teams are discipline based and long term in their collaboration.	Knowledge is produced diverse organisational contexts, including universities, non-university research institutes, government agencies, not for profit organization, industry, and consultancies. Research teams are transitory and diverse, incorporating people with a range of skills and experiences as necessary. The composition of teams changes as problems evolve and new issues emerge.
Accountability and Quality Control	Researchers are accountable to and judged by their peers through peer review. The scientist is seen as expert, disseminating knowledge to a largely uniformed and undifferentiated public. Quality is based on notion of scientific excellence, measured against existing disciplinary cognition and norms. A key consideration is whether the research is seen to contribute to the discipline.	Social accountability permeates the knowledge production process. The research process reflects the interests of diverse stakeholders. Quality is judged on a broad range of criteria, reflecting wider social interests and diverse composition of review system. In addition to intellectual merit, research is judged in terms of cost-effectiveness and economic and social relevance. Quality control is context and use dependent and reflexive, adapting to local contexts and changing circumstances.

2.3. THE "TRIPLE HELIX"

The previous sections have described the Mode II Knowledge Production and the collaboration for innovation. The Mode II Knowledge Production involves participants with different types of knowledge. In many cases this involves collaboration with participants from different types of organizations. The Triple Helix deals with the collaboration between university-industry-government. An introduction to the Triple Helix concept is necessary, for the developed model in chapter 5 has Triple Helix as its ingredient. Moreover, the case study of this thesis is the Co-operative Research Centre, a typical collaboration between university-industry- and government. The Triple Helix concept describes such collaboration as follows:

> "the Triple Helix takes the traditional forms of institutional differentiation among universities, industries and government as its starting point. The Triple Helix takes the account of the expanding role of the knowledge sector in relation to the political and economic infrastructure of wider society. The institution can be considered as the fingerprints of the communication patterns that have been functional for the reproduction of the system hitherto. The functionality of differentiation, however, leads its longer-term institutionalization. Thus one can distinguish between institutional differentiation and functional differentiation in communications within and among these institutions". (Leydesdorff, 1997, p:107)

Thus Triple Helix concept considers the collaboration from communication perspectives. While the topic of the communication is described by Leydesdorff as follows

> "What is communicated in these relations? There are three dynamics. These are: (1) the economic exchange on the market; (2) the internal dynamics of knowledge production and innovation (which tends to upset the movement towards equilibrium); and (3) institutional governance of the interface at different level. One implication of Triple Helix is the analysis of the institutional binding forces among different yet interacting dynamics". (Leydesdorff, 1997:p 107-108)

Leydesdorff mentions the role of a new institution in bridging two different codified systems as follows,

> "the so called scientific-institutional revolution takes place at the institutionally organized interface between two functionally codified systems. That is, science and the economy. The new institutions (e.g corporate laboratories) provide the basis for an interaction between the codifications. Sustained interaction is expected to change the codification mutually. Economic selections can be discussed in terms of representations (e.g: utility function). Scientific and technical selection can no longer be considered as exogenous to this economic system. (Nelson and Winter, 1982) Thus the two functions can provide each other with resources and feedback on the basis of their organization within an institutional framework. The institutional organization between the two functional codifications allow for a helix of *translations* which can be carried out at local interfaces. (Latour, 1987) In a system of translations, scientific communications are no longer selected only in terms of their "truth" value as their intrinsic codification, but also in terms of their utility as another codification". (Leydesdorff, 1997:p 110)

The need to have such institution is namely to help translate the different codification used by different participants in collaboration. For example: the university participant would communicate by using scientific codification, while industry participant would communicate with economic codification. A collaboration by taking both university and industry requires a 'translator' that can function as translation medium. The following quote explains more the need to have such a translator which enables a functioning communications among participants having different codification,

> "in a system of translations, the dispute between different perspective is institutionalized. The institutionalization of a translation system can lead to a highly scientific second order communications. This will reinforce mutual understanding and thus self-understanding at lower levels of interaction. This will enable the carrying agents to specify reflexively what may function as a signal at the next higher level and what may be discarded as noise". (Leydesdorff, 1997:p 111)

Moreover, Leydesdorff stresses the difference between the translation system and ordinary communication system by stating that,

> "the translation system is thus different from the ordinary communication system. The difference is illustrated as follows. Figure 2.1 depicts three systems, which have common intersection. The circles represent the different spheres of communication (with respective codification) that are possible in pluriform society. In terms of communication processes, one may think of the intersection as the common language (a), for example the venacular, in which all specialist jargons (ab and ak) can

> be translated if sufficiently elaborated. In figure 2.2 differentiation has proceeded to such an extent that first, the common zone of interpenetration has disappeared. Second, the integrating system is depicted as hyper-cycle that can be generated by a series of selections which the various communication systems employ in relation to each other. However the hyper-cyclic communication is not expected to exist at any single moment. It is an emerging system, and indeed in this case integration requires more complexity than differentiation. The system is integrated over time; at each moment in time only a distribution of communication can be observed. The integrating instance can no longer be observed since the selections can occur in different directions, and thus various cycles may coexist. Each system can perceive itself as the integrating instance, since the criteria for integration are different among systems, and the time horizon may be different as well. Integration over time always implies a translation at a receiving end as the system of reference". (Leydesdorff, 1997:p 111-112)

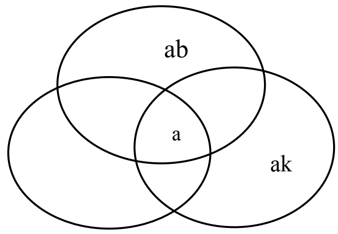

Figure 2.1 Differentiation (ab/ak) and integration (a) of communication
Source: slightly modified from Leydesdorff (1997).

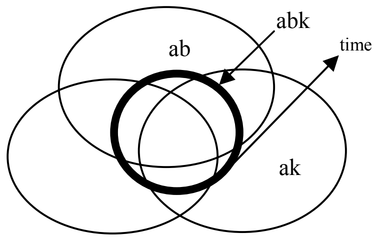

Figure 2.2 Differentiation (ab) and translation (abk) of communication
Source: slightly modified from Leydesdorff (1997).

The process of communication in translation system is different than in ordinary communication system as Leydesdorff notes,

> "unlike an ordinary communication system, where the individual can participate in the communication, in a translation system, communication is based on the reflexive selection among other communications. The carriers of the original communications are represented in a system of translation only in terms of the quality of their communication among other communications. In other words, translation operates on representation. The translation systems are not selective with respect to intentional actors but only with their communications. Thus the translation system contains an additional degree of freedom when compared with a communication

> system; translation systems are expected to handle more specificity and complexity in the communication than communication systems. Thus, one is institutionally warranted to change the code of the communication with hindsight if that is *appropriate for solving the puzzle under study*. Initially these changes of codes can be supported by divisions of labour in the relevant techno-structures. The crucial step, however, is the establishment of competencies of communication among the communicators that make it possible for the subjects involved to internalize the anticipation of subsequent selections on each other's communications. Thus the subjects are sorted in terms of competencies for specific communications. (Tobias et al, 1995; cf. Habermans, 1981)" (see: Leydesdorff, 1997:p 112-113)

Leydesdorff explains the difference between functional and translative integration as,

> "functional differentiation and translative integration are mutually contingent upon each other, but the operation is different. The functional differentiation requires the codification of the communication and therefore the distinction between substance and the meaning of the information. The high-tech sciences require hyper-cycles of communication in at least three dimensions. "Triadic" communication systems (abk) are able to encompass the functionally differentiated ones, and to translate them asymmetrically into each other (ab-ak) (see figure 2.2). Thus they are able to change the code internally, and by evolutionary alternating between codes they seem to reconcile what was irreconcilable from the perspective of the previous episteme". (Leydesdorff, 1997:p 113)

The translation system can thus translate the codification based on the need of the participant. For example what is communicated by university under scientific codification can be translated in the codification of the industry and vice versa. This requires operation of translation which is different than ordinary communication.

"In general, a translation has different functions for various interacting sub systems. Translations are asymmetrical: the systems interact, but thereupon each of the interacting systems is reproduced in its own terms. Reflexive translation systems are able to learn from their interactions because the translated system is represented within the translating system so that the latter can act on former selectively. Thus translation system are able to strengthen their internal dynamics in the complex environment of other translation systems". (Leydesdorff, 1997:p 115)

Leydesdorff and Etzkowitz discuss the application of Triple Helix in the academic, industrial and government institutions by noting that,

> "in the Triple Helix, academic, industrial, and governmental institutions each contain communication structures and culturally encoded messages that are sometimes difficult for outsiders to interpret. Translations between institutional codes are highly specific. The Triple Helix operates in terms of translations among specific communications and therefore in highly selective transformations of institutions, the helices drive each other in terms of specificity and selectivity". (Leydesdorff and Etzkowitz, 1997:p 159)

Leydesdorff and Etzkowitz note that "as reflexivity is further pursued and institutionalized in terms of systematic R & D, a knowledge based economy is increasingly generated. Science based innovations continuously reshape systems at more than a single level. In this context Turpin and Garrett-Jones (1997) have used the concept of systematic-disorganisation of existing innovation networks during the 1980s. Institution formation is a necessary complement and corrective to theories of random, stochastic processes of social change. The reverse side of the coin of creative destruction (Schumpeter, 1943) is institution formation (Etzkowitz, 1970): the design and construction of new organizational formats as well as the reformation of old ones. The institutional and functional levels operate on each other selectively during the processes of mutual adjustment". (Leydesdorff and Etzkowitz, 1998b: p. 359 and p 362) Leydesdorff and Etzkowitz further explain that,

> "for example: an institutional arrangement can be organized with reference to its functionality for further development, whereas selection among possible combinations of expectations is done on the basis of institutional strength and weaknesses. The two levels provide the necessary variation for making mutual selection processes possible. Such a dual layered system may propel its own dynamics in a process of self-organization (Maturana and Varella, 1980; Luhmann, 1994). The two layers are complex in themselves. The functional differentiation among

> economic, political, and scientific considerations and the institutional interfaces among industries, academic disciplines and government offices constitute sufficient variation for the mutual selections and these dynamics can further be reinforced by interaction terms. While it is volatile as a system of communication, society is also continuously in need of institutional reproduction. The continuation is based on internal differentiation, while different sub dynamics integrate by using their selective operations that is by invoking their specific codes. Control remains, however, a relevant category at each moment. It is a consequence of the need for reproduction of the dynamics". (Leydesdorff and Etzkowitz, 1998b:p 362)

Leydesdorff and Etzkowitz mention the understanding of innovation from Triple Helix perspective as follows,

> "from a Triple Helix perspective, innovation can be considered as the reflexive re-combination of specific contexts, for example, between a technological option and a market perspective. For the purpose of innovation the perspective have to be translated into each other, for example in terms of a strategic plan. The translation potentially reinforces the research process by raising new questions, for example by comparing across different contents yet with reference to emerging phenomena". (Leydesdorff and Etzkowitz, 1998a:p 197)

From the previous explanations it is clear that in Triple Helix model, there is a need to consider both the substance of communications and codes of the communications. The codes are basically from the codifications of the communications used by each partner participating in the communication. The role of the translation system is to translate the codes, as Leydesdorff and Etzkowitz explain,

> "by translating between codes, translators communicate reflexively about communications at the interfaces. Strategic communication now open new windows by combining perspective, while the institutional dynamics adapts selectively. When three uncertainties operate on each other as among markets, sciences and control, new combinations enable the survival of niches, which are superior to the natural fits yet unexpectedly and from a global perspective. The Triple Helix implies that the paradigm of research in innovation studies has definitely incorporated a network mode including uncertain relations with a plurality of environments". (Leydesdorff and Etzkowitz, 1998a:p 200-201)

In the Triple Helix, each Helix consists of communication process and the dynamics of the process is dependent on the code used, as Leydesdorff and Etzkowitz mention,

> "the helices contain communication processes, which select on the interactive dynamics perceived at their borders using their respective codes to provide the new information with specific meanings. The different codes can be shared at the interfaces, and sometimes a transient arrangement can be institutionalized. Niches for knowledge intensive industries are thus created and sustained. Innovation is initially the result of a local interaction between scientific invention, economic diffusion and political power. Innovation systems are expected to develop further based on reflexive translations. The transformations challenge the analytical understanding as they transform the conditions of the emerging achievements". (Leydesdorff and Etzkowitz, 1998a:p 201-202)

The above described theories suggest the need to have a translation system. This translation system must be able to translate the codes form different participants in the collaboration and combine the codes so that each participant can understand the process of communication. The idea that innovation is an arena of information transaction is manifested in the process of communication, because the method of transacting the information is mostly conducted through this communication. What is being communicated must be done as such so that each participant can understand the other. This requires an excellent translation system, which has to be able to operate reflexively, as suggested by the above described theories.

In summary, the Triple Helix has the following features: (a) there is a communication process being discussed; (b) there are some layers in this communication process; (c) there is selection among layers; (d) there is a reflexive translation system being needed; (e) all of those things must be based on the functional differentiation rather than institutional differentiation.

2.4. CONCLUSIONS

In general, the current dynamic environment has forced many firms to collaborate as an attractive way to reduce costs, sharing risks and increasing opportunities in this unpredictable situation. This chapter has described the reasons for firms and organizations start collaboration especially technological collaboration, in order to deal with current global challenges. In many cases this kind of collaboration has been extended to participants from different types of organizations, which means participants with different skills, knowledge capacity, etc. Getting more innovative is one of the most important criterions to survive in the current world economy. Firms and many other organizations including governments are pursuing this goal in several ways and one of the best alternatives to achieve this objective is through collaboration.

This chapter has described Mode II Knowledge Production. In Mode II emphasis is given to the trans-disciplinary aspect, which involves different participants with different expertises and skills in the process of the production of knowledge. The Mode II, especially in its concept for conducting a collaborative research partnership will be used as an analytical tool in the subsequent chapters of this thesis. The current trend of the world economy has shaped the situation as such, that Mode II emerges as an alternative to deal with a more dynamic environment and its challenges. Combined with the concept of Mode II this strengthens the argument where collaboration can be assumed as a process of different types of information being transacted to achieve a particular goal (for example: to become more innovative).

This chapter concludes that the collaborative network based on Mode II is very attractive to make participants to become more innovative.

Moreover, Mode II with its reflexive character offers the best solution in dealing with all problems in the current very dynamic economic situation. The reason for this and the benefits for creating an innovative condition of collaboration based on Mode II have been explained. Furthermore, Mode II relies on intensive communication for knowledge exchange among actors involved in the collaboration. This again strengthens the argument that in Mode II the basis of its activity is information transaction. This last part suggests the need to have an excellent process for this information transaction. In Mode II this communication is crucial. The participants involved in this type of collaborative research network come from different institutions which have different methods of communication. Mode II suggests that a good and modern communication system is compulsory for a successful collaboration. This good communication system is required to help in the process of information transaction among participants in the collaboration, who are using completely different methods of communication.

This chapter has introduced the method for analysing the communication among participants from university-industry and government agencies, a type of collaborative arrangement, which is to be explored more in subsequent chapters. A metaphor which is called the Triple Helix has been introduced, which is complex enough to encompass the collaboration which involves participants from university-industry and government agencies operating under Mode II. The basis of Triple Helix metaphor is the communication between actors in the collaboration especially from university-industry and government agencies.

Having collaboration under the Mode II operation requires a dynamic changing of the codes in the method of communication used within the web of collaboration. The Triple Helix allows for a reflexive mode of exchanging codes (in the used method of communication) among these participants, making this type of methodology useful for analysing a collaborative partnership under Mode II.

CHAPTER 3. INFORMATION, COMMUNICATION FOR INNOVATION, AND TRIPLE HELIX COLLABORATION: THEORIES AND SOME EXAMPLES.

The previous chapter has described the relationship of collaboration and innovation. It has raised two main concepts namely: Mode II Knowledge Production and the Triple Helix. Both concepts have been connected to the collaborative research partnership towards innovation. Both concepts have raised the importance of information within the web of collaboration for innovation.

This chapter discusses the role of information in the process of innovation through collaboration. Furthermore this chapter also discusses how information flows in the collaboration and has a role in the innovative process. This chapter takes some examples of collaborative partnerships involving peoples from different organizations. An analysis of how information flows and what the main types of information are which drive the entire collaboration, will be discussed.

Section 3.1 explains some theories from the literature on the role that information plays in innovation. This is followed by a discussion on the role of information flows in collaborative research partnerships in section 3.2. Section 3.3 discusses the information and its process of transaction through communication and the role of the Internet. Section 3.4 presents some examples of the Triple Helix collaboration with the analysis of information flows within the Triple Helix. Section 3.5 gives some conclusions.

3.1. INFORMATION FOR INNOVATION

This section discusses the following issues: the characteristics of the information required for innovation and the required activity to capture or generate the required information for innovation. The main objectives are to determine what type of information is required for innovation, when this type of information is required and how it differs from different actors in the innovation process and how this type of information may change in the process of innovation.

Macdonald notes that "the organization is an information organism. Some would say, that dealing with information is the whole purpose of organization: more than the organizations do not prosper unless they are at least able to cope with information". (Macdonald, 1996, p:221) Furthermore, Macdonald (1998, p:262) also defined that "the organization requires different types of information". In relation to information for innovation, Johnston and Gibbons (1975) note, "that different types of innovation will produce problems requiring a different mix of information to solve them and hence display a different source usage pattern". (see Hill 1982, p: 128) Moreover Macdonald states,

> "that the information network permits multilateral exchange, which clearly gives access to much more information than would be available from any single individual. Individuals may draw information from any part of the network, from any other member, in return, they must contribute information". (Macdonald, 1998, p:23)

Hill (1982) notes that,

> "there are three important aspects in information with regard to innovation. The first is channel of information, for example: personal contact, senior management, salesman and information-unit. The second one is the sources of information, for example: people, publication, internal reports and outside agencies. The third one is the types of information, for example: scientific, technological, legal/regulatory, environmental/health and safety, financial, social and market. All will vary with time

> and vary from one innovation to another. Information is a key to successful innovation". (Hill, 1982, p: 128)

Moreover, Maguire et al, (1994, p:152), note that, "from the literature, there are the following important sources of information for innovation:

- Internal sources
  - Peers (formal and informal interactions) including those in other departments of an organization, as for example planning and marketing personnel for R & D staff.
  - New employees
  - Internally generated data and reports

- External sources
  - Peers (formal and informal interactions)
  - Meetings, seminars, conferences, study missions
  - Publications
  - Electronic Information Services."

Maguire et al, add that,

> "a distinctive characteristic of an innovative organization is that they encourage and facilitate the information flows that innovation requires. Although informal flows are critical, formal sources of information are needed to complement them". (Maguire et al, 1994, p:273)

While, Macdonald notes that,

> "if innovation is a new pattern of bits of information, it is legitimate to ask whence come these bits, how they make their way from their sources and how they are formed into a new pattern. No matter how rich the external sources of information are, no matter how vital for change the information they contain, nothing can happen unless the information is transferred to where it is to be used. There are only two ways by which information can exists in any location: it was created there or it was transferred there from somewhere else". (Macdonald, 1998, p:57)

Macdonald stresses, "that information must be transferred in the expectation that destination has created or acquired the extra information needed to fill the package to complete the information pattern". (Macdonald, 1998, p:73)

Gibbons et al state that,

> "in the innovation process, access to accurate, up to date information has always been important. But, in the emerging regime, the process of generation, acquisition and diffusion of information will be more and more mediated by information technology systems. Competence in innovation is being re-defined in terms of the ability to solve problems by selecting relevant data and skills and organizing them appropriately. When information is plentiful, perhaps too plentiful, competence does not derive from being able to generate yet more, but from the insight gained by arranging what exists in novel ways". (Gibbons et al, 1994, p:64)

Information for innovation is a matter of management, according to Van Houten, it is a management to select from various alternative strategies and the choice of alternative strategies will influence the type of information required for innovation. (Van Houten, 1982, p: 75) In practice the relation between information and innovation process is reflected in the role of R & D establishment from information perspective which is described by van Houten (1982, p: 75) as follows:

- "the listening post (to tap with latest information from external sources for the benefits of innovation)
- the interdisciplinary role (to provide a room, for a possible integration for different disciplines)
- science and technology application at lowest cost in time and effort
- technology transfer
- the feasibility appraisal role."

In term of types of organization, van Houten differenciates the nature of information for innovation between the R & D labs of Public Sector Research (PSR) Agencies and Industries. For PSR, information for innovation is of open nature while for industry it is of cost-conscious and as commodity. (van Houten, 1982, p: 76). This difference implies that each partner of CRC collaboration would have different perspective in viewing information for innovation. Moreover Van Houten stresses that, "..an R & D establishment has to rely on large inputs of information from external resources". (van Houten, 1982, p: 76). Van Houten further mentions that in relation to external information,

> "…both industry and PSR needs to improve the usage of it, which can be conducted by several activities, such as establishment of in-house libraries, correspondence information, monitoring and business intelligence system, establishment of technology transfer points, advisory services and the support of documentary information services and the encouragement of industry to use external research and development and external information sources". (van Houten, 1982 p: 76)

Furthermore to maximize the usage of information for innovation, Schumacher notes that there are,

> "…three function in information sector that has to considered, these are: the generation (production) of information, the dissemination (transfer) of information and the implementation (application) of information".(Schumacher, 1982, p:84)

Those three functions are the basic for the process of information flow for innovation in any organization, including in Australian Cooperative Research Centre. Schumacher further defines that the flow of information can be categorized in two types, these are,

> "the notion of information transfer implies two types of information flow: (1) information push, i.e. newly generated information is offered to a wide range of potential users, to whom it may concern; (2) information pull, i.e. a particular users is demanding specific information, wherever it may be retrieved from. However, there is the danger of "information pollution". This is a condition where a large information repository (e.g: a huge database) is created but is not used properly, because the user domain is too small. He also notes that there is a close relationship between the way information is handled by a country and its rate of innovation, as no innovation without information and no novel information without innovation. Both information and innovation need freedom in order to be viable and productive". (Schumacher, 1982, p:86)

The role of a third party that can bridge the information flow in innovation process is indicated by Schumacher as follows,

> "the need to have an information broker in the innovation process. The role of information broker is to bridge the gap between all those involved in information

> and innovation process. The broker's job is to search for all wanted information by all available means". (Schumacher, 1982, p:88)

The establishment of a CRC can be considered as a broker of information flow as indicated by Schumacher (more on the CRC in chapter 4).

The type of information required for innovation is dependent on the stages of innovation process, as Hill notes that,

> "information for innovation covers a very wide range of inputs from alerting a firm to the need to innovate through the provision of technical data to the analysis of market data. The information requirements of each step in the sequence of events, which together make up the innovation can be very different. Further, the information relevant to a particular step has to arrive at the right time for that step. Also there has to be constant updating of the information being used to ensure, for example that the innovation does not proceed down to a channel suddenly rendered profitless". (Hill, 1982, p:27)

Hill further defines the difference of the required information in different stages of innovation process as follows,

> "the following stages of the innovation process with its information requirement:
>
> (1). The conception phase. During this phase there is an importance of accepting information from outside. This can be achieved by hiring new people to work with the firm or by sending own people to another company, seminars or conferences. The usage of literature is not quite so intensive…. Another source for innovation is collaboration with another company. This may take the form of a joint project or of buying a license, usually acquiring in this way both manufacturing rights and technical know-how and then improving the product and the process.
>
> (2) The technical realization phase. In this phase the information required for the innovation comes normally from within the organization. The information is mostly gathered on technical problems basis and acquired from people working on the project. Personal contacts and information exchange between people working in the 'floor' and planner is required". (Hill, 1982,p: 25)

Moreover Hill also requires the following fundamentals for a successful innovation process.

> "First, there must be a ready flow and willing acceptance of information within the organization. Secondly, there must be good channels for and ready acceptance of information whether from outside or inside the company. Thirdly, reliable answers to specific problems that arise during the innovation process should be given. Fourthly, arrangements are made so that information is drawn from all appropriate sources and made available in or circulated to R & D staff and others in a suitable form. Fifthly, those who like to use information themselves should get access and facilities to it". (Hill, 1982, p:26)

The task for the information broker (including CRC) in the innovation process may consist of providing such conducive environment as indicated by above quotes.

From the previous literatures it can be concluded that there are several main considerations for information in innovation. Firstly, there are some requirements for information in innovation. Secondly, there is a need to have a channel for this information and finally a process to create innovation. In term of what type of information, it is interesting that the information for innovation must be information which has economy values. This type of information which is required for innovation must normally be gathered from outside the organization. In the innovation process the need is to arrange the information already available in novel ways rather than creating a totally new type of information. The ideas from Macdonald, Gibbons, van Houten, Ljunberg and Hill suggest the need to conduct this innovation process by involving different partners in a kind of collaborative arrangement. However in such an arrangement there is a need to have a common understanding of the meaning of information for all partners. It is postulated that this requires the existence of a "translation media", which is in a position to make sure that all partners have the same understanding of the meaning of all the information. This "translation media" may help reduce the risk of information pollution and also the negative use of information.

In such innovation process the need to have particular information is dependent on the process's stages. Moreover there is a need to make sure that information arrives at a place where it is required.

Thus it can be hypothesized that a relationship among participants in the collaboration on the basis of information transaction does exist. The reasons are, (1) that there is a need to have the information at the right time and right place; (2) that the type of information required for innovation process is dependent on the process's stages; (3) that there is a possibility that each participant has a different interpretation in the meaning of each bit of information in the innovation process; and (4) each participant in the innovation process possesses different types of information.

To gather information for innovation is to gather it from outside the organization. Practically, the best way to achieve this, is by providing a channel for information, through collaboration. Both formal and informal channels are important. When a participant is entering such a collaboration, then it is likely that the relationship is based on an information transaction. In the process of information for innovation, there is a need to have a translation media. The main reason for this is that when the participants are transacting information, there is a need to have a real time interaction between participants on a given subject with a common language and a common thought model plus the need to make sure that any required information will arrive in the place where it is required and ready to fill that 'gap' of information, there is thus a need to have a translation media.

Moreover, this translation media is hypothesized to be able to create a conducive environment for innovation, that is an environment where there is free flow of information; the information is ready to be used; and information is well understood by participants.

To summarize, the information which is required for innovation must be the information collected from outside the organization which has economic values. The best way to gather this information is by using collaboration provided there is a guarantee that all participants understand each other in regards to the meaning of each bit of information. Based on these two facts there are two main considerations: there is likely to be a relationship among participants on the basis of the information transaction and there is a need to have a translation media.

3.2. COMMUNICATION, INNOVATION AND THE INTERNET

This section describes the process of information transaction in the collaboration for innovation. The most common method of information transaction is through communication. The subsection 3.2.1 deals with innovation and communication. This is followed by subsection 3.2.2, which deals with the role of Internet in the process of information transaction.

3.2.1. COMMUNICATION FOR INNOVATION

As has been described in the previous section, collaboration can provide a conducive environment for innovation and there is likely to be a relationship among participants based on the information transaction in the process of this innovation. This section discusses the concept of the information transaction in a collaboration. The main objectives are to introduce the importance of the information transaction and the role of collaboration in the innovation process. This section also discusses the communication system by the use of the Internet, which is very important in order to enhance the process of information transaction (including through communication) in the collaboration for innovation.

A study conducted by Brown and Eisenhardt illustrates the role of communication for innovation specifically for product development process as given in the following quote,

> "….external communication (communications between team members in product development with outsiders) is critical to successful product development…Similarly, internal communication (communications between team members of product development), improves development team performance."(Brown and Eisenhardt, 1995, p:358)

Moreover, Brown and Eisenhardt describe that,

> "…. frequent and appropriately structured task communication (both internal and external) has been found to lead a more comprehensive and varied information flow to team members and, thus, to a higher performing development process". (Brown and Eisenhardt, 1995, p:358)

The two previous quotes indicate that to be successful in providing innovation, communication process has to be structured in appropriate way. This means that collaborative research or activity where there is an intensive communication, requires a good management setting in communication.

As explained in chapter 2, Mode II puts strong emphasis on the collaboration with a transdisciplinary context and according to Gibbons et al (1994) the relation between communication and innovation can be described as follows,

> "communication plays a central role in his Mode II mechanism. And the density of communication appears to be a key variable". (p 34) ……An increase in the density of communication is an indication that the rate of diffusion is increasing and given a multitude of different sites of knowledge production and sufficient diversity among participants, growth is likely to be heterogeneous rather than homogeneous". (Gibbons et al, 1994:p 35)

Other scholar, Antonelli recapitulates several important relationships between communication and innovation capabilities as follows,

> "The institutional context of economic systems in terms of communication conditions plays a major role in assessing their innovation capabilities. Access to external tacit and codified knowledge depends on the extent to which effective communication among innovators takes place through the innovation system. In this context the properties of economics systems, conceived as communication networks into which information flows, matter in explaining the capability to generate new technological knowledge" (Hayek, 1945, Lamberton, 1971, 96.97) (Antonelli, 2000, p:540)

The previous quote illustrates that the process for generation of new technological knowledge can be considered as communication networks. Thus a management setting in such communication networks should be very critical in order to enable such network producing innovation. In relation to communication networks, other research conducted by Nobel and Birkinshaw (1998) show that different types of R & D labs (R & D lab of a local adaptor, internal adaptor and international creator[1]) use different modes of communications. R & D lab of local adaptor communicates mainly with other local R & D institutions, local customers and local suppliers (Nobel and Birkinshaw, 1998, p: 488), while international adaptor communicates mainly with other international adaptors from other countries (Nobel

[1] *Local adaptor* is a support unit which helps the local producing unit to assimilate and effectively utilize the existing mainstream technology to the Multi National Company; *International adaptor* is a locally integrated laboratory which provides backup for a local producing unit, but aspires to a more fundamentally creative role than a support laboratory, seeking to endow its subsidiary with some kind of product autonomy; *International creator*, is internationally dependent laboratory which provide inputs into a centrally defined and coordinated R & D program, with no necessary connection with host country producing operations (Pearce, 1991, p:14-15)(from Nobel and Birkinshaw, 1998, p:481-482)

and Birkinshaw, 1998, p:489) and international creator communicates mainly with local universities, foreign customers and foreign suppliers (Nobel and Birkinshaw, 1998, p:490).

The communication which is conducted by the scientist within the network of communication is influenced by two factors as indicated by Gibbons et al as follows,

> "The first one is their mobility, while the second relates to how they set priorities and select problems (selectivity). Mobility, is an essential pre-condition for cross-fertilization of scientific ideas and know how. Scientists moving between different sites of knowledge production exchange ideas and know how, and learn about new techniques, devices and principles. Numerous instances of scientific creativity of sudden insights and the opening up of novel pathways towards solutions can be traced to encounters between scientists brought together from different sites. The more mobility a science system permits or even encourages, the more potential instances of this kind can be expected". (Gibbons et al, 1994, p:38)

Albertini and Butler (1997) define in more detail, the type and used mechanism of communication in R & D collaboration by differentiating the phase of research. Table 3.1 (see page 60) lists all the different kinds of methods for information exchange for the different types of information being exchanged. The last is dependent on the phase of research and thus the objective of research. Table 3.1 also lists the relationship between types of information and methods of information being exchanged which are dependent on the type of research being conducted. The type of research being conducted also reveals the different type of main type of information as its objective.

Table 3.1. The type of information and used mechanism of information exchange for different types of R & D collaboration. Source: compiled from Albertini and Butler (1997).

Phase of R & D	Objective	Type of Information being exchanged	Used mechanism of information exchange
Speculative Research	Target Discovery	• General information about the broad range of R & D work • Abstract and strongly dependent on tacit skills ('know-how' and personal culture and creativity) • Instrumentalities (available instruments and associated capabilities to set-up, construct and interpret the test results)	• Interpersonal communication (e.g.: scientists working together every day in the same laboratory) led by 'regulation oriented' managers (preferably non sceptic and with very good research skills) • Structure of used mechanism is informal and flexible
Explorative Research	Compound Discovery	More specific but still often tacit. The network can produce new codified and network specific information or codified general information. A strong process of transformation from tacit to network specific information.	Informal at the beginning but will evolve to be formal at the later stages
Exploratory Research	Early Development	• Explicit (formal and codified) information • General information about how to exploit the work further	Formal at the beginning but could be informal at later stages
Exploiting Research	Late Development	• Specific information directly oriented to a defined objectives • Explicit (formal and codified) and also transferable	Formal and rigid (very formal between partners, such as regular meeting, regular conferences etc)

In summary, not all communication conveys knowledge and communication in R & D should be done appropriately by considering the type of R & D labs. The following R & D strategy characteristics should be included: the type of people communicated with; the type of R & D; and the team composition. The next subsection discusses the role of the Internet in the process of information transaction.

3.2.2. THE ROLE OF THE INTERNET IN COMMUNICATION FOR INNOVATION.

The current available communication system has increased the possibility of conducting an extensive information transaction by better communication in the collaborative program for innovation. Theoretically, Gibbons et al note that Mode II is critically dependent on the emerging computer and telecommunication technologies and will favour those who can afford them (Gibbons et al, 1994, p:122)

In relation to the role of Internet communication for innovation, recent scholar Teresko mentions that currently there are several Internet tools which allow manufacturers to join forces to enhance individual strengths. (Teresko, 2000, p:31) Teresko illustrates the influence of Internet in easing the collaboration as follows,

> "Today internet-enabled collaboration is creating a fundamental divide in the practice of global business and the management structures that guide it. To see as great a sea change would require revisiting the 19^{th} century invention of the telegraph. Before that time people collaborated across distance only as quickly and easily as the fastest horse or ship permitted." (Teresko, 2000, p:31)

Michael Gibbons et al also raise the importance of computer based telecommunication technology as very conducive to enhance the collaboration as follows,

> "…the mobilization of varied skills and perspective in the solution of complex problems is being built around the clustering information, computer telecommunication technologies" (Gibbons, et al, 1994, p:113)

Borck (2000) suggests the term of E-collaboration, that is a collaboration with an extensive support of Internet communication. Borck further indicates that,

> "…..interactive collaboration tools can give effective competitive and cost-saving advantages to organizations that deploy them properly because they streamline interactive project management. Internet and intranet solutions are powerful and can be extended to outside partner…"(Borck, 2000, p: 73)

The other main role of Internet communication is to cope with floods of information as indicated by Waltner (2000, p:117). Currently there many Internet based softwares that are available to support collaboration especially in dealing with difficulties of sharing, filling and indexing the most common document, web-pages and attachments (Waltner, 2000,p: 117). Other Information-analyst A. Gilbert strengthens Waltner's comment by adding that an extensive usage of Internet allows the companies and businesses to speed the development and innovation by sharing data. (Gilbert, 2000, p: 130) Gilbert further mentions that "..web (thus Internet) is the driving force behind many collaborative business process…"(Gilbert, 2000, p: 132).

In relation to the increasing role of Internet as communication means in collaboration other analyst J. Teresko notes that, "a new collaborative model is also re-focusing on solution providers. With the advent of the Internet, business software firms that once offered solutions for integrating the enterprise have moved to offerings that integrate companies with their out-sourcing partners and others constituencies". (Teresko, 2000, p:31) He notes that, Internet collaboration may reduce the cost of outsourcing. Big savings accrue in transactions with any business constituency-supplier, customers, stockholder, or government". (Teresko, 2000, p:32) "The savings not only benefit the cost of procurement, but also time to market, innovation, and customer intimacy". (Teresko, 2000, p:32) In Teresko case study it is concluded that,

> "….. every business is divided into three core processes: customer relationship management, product innovation, and infrastructure management. In a traditional

> organization all three are bound together by high interaction or transactional costs. From a strategic point of view, Singer sees the collaborative power of the Internet empowering manufacturing managements to creatively seek alternatives". (Teresko, 2000, p:32)

In summary, this section has described the aspect of collaboration for innovation from an information perspective. Most literature agrees that collaboration is supportive in gathering information from others and creating a conducive environment for innovation. Moreover it has been discussed that Internet technology is indeed important in simplifying the process of information exchange in the collaborative partnership towards innovation. These ideas will be further explored in the case studies.

3.3. SOME EXAMPLES OF THE TRIPLE HELIX MODEL IN THE WORLD ECONOMY

Sections 3.1 and 3.2 described the communication and information aspects of collaboration for innovation. To present a clearer picture of how this Triple Helix works, especially from an information perspective, this section introduces some selected examples of collaborative partnerships in the Triple Helix. The objective of this section is to examine in more detail the evidence that there are several Triple Helices that can exist and thus a variety of information requirements that might exist. The countries under consideration are:

1. France with its Biotechnology industry,
2. Canada with the Telescope Mega Project,
3. Brazil with its Software industry,
4. Australia with the Mining and Coal industry.

These examples are sourced from the literature.

EXAMPLE 1: FRANCE WITH ITS BIOTECHNOLOGY INDUSTRY

This section describes a collaboration in the Biotechnology industry in France. (Staropoli, 1998) "The company's name is Rhone-Poulenc Rorer-Gencell (RPR-Gencell), which is an integrated division of Rhone-Poulenc Rorer (RPR) Inc. The RPR is a publicly traded global pharmaceutical company dedicated to the discovery, development manufacture and marketing of human pharmaceuticals. The RPR-Gencell specializes in biotechnology and is organized as a formal network with 18 public and private partners". (Staropoli, 1998,p:17) The work conducted by RPR-Gencell to do research in gene therapy is organized into a network with the following actors. (Staropoli, 1998, p:17) (figure 3.1):

- Smaller independent R & D laboratories specializing in bio technology both in France and in the United States.
- Several government owned laboratories.
- Several universities owned laboratories.

The main reasons for the establishment of the network and collaboration are as follows: (Staropoli, 1998, p:18)

- "The work in gene therapy is a technological gamble. Uncertainties (both in technology, financial and innovation processes) are so strong and ethical issues so important that they could destroy all efforts.
- Optimization of existing technologies and relationship. RPR-Gencell has been created by optimizing existing technologies and co-operative relationship but also by generating synergies among corporate partners activities.
- The diversity of partners as an adaptation to financial constraint and a way to create a technological 'toolkit'. RPR-Gencell is an interface between academic labs and their corporate partners. Partner diversity gives flexibility with respect to financial constraints and risks since it diversifies financing.
- Institutional diversity. Due to location of partners at the different sites, RPR-Gencell is also an interface between French and US public-funding, French and US regulations also French and US venture capitalisms. The benefit of this institutional diversity is that it can overcome rigidities while taking advantage of different national policies".

"In the case of RPR-Gencell all participants involved (several small independent R & D labs, government labs, and universities labs from France and United States) are conducting work in the form of a federation of interdependent multilateral contracts (given by RPR-Gencell). This partnership diversity and the interactivity among all participants of the network, based on specific relationship and technological synergies, reinforces the interdependence between the participants and the cross connection, both enabled by network format". (Staropoli, 1998, p:18) For RPR this kind of method is very beneficial because: (Staropoli, 1998, p:18)

- "The barriers to entry are raised since competitors will not have the opportunity to easily contact incumbent actors in the market while R & D operation is crucial.
- The number of potential partner for other companies is reduced and this should help RPR to maintain its position, which could result in leadership in the field of gene therapy in the mid/long term".

"The specific relationship between RPR with the French government is established through BioAvenir. BioAvenir is a government agency which aims at encouraging co-operation between private and public R&D and at supporting national research". (Staropoli, 1998, p:18)

Table 3.2. Summary of the required type of information in the French example tabulated in three groups of partner according to Triple Helix. Source: Author compiled from Staropoli (1998).

Government	Industry	University
<u>Bio Avenir :</u> 1. Progress reports 2. Achievement reports in the field of biotechnology from RPR Gencell and its alliances <u>Public R& D Labs:</u> 1. Facilities, equipment, expertise and human resources available to conduct R & D work in biotechnology 2. Detailed programs in biotechnology R & D work ordered by RPR-Gencell	1. Facilities, 2. Equipment, 3. Expertise, and 4. Human resources available to conduct R&D in biotechnology from government, universities and private labs engaged in contracts	1. Facilities, equipment, expertise and human resources available to conduct R & D work in biotechnology 2. Detailed programs in biotechnology R & D work ordered by RPR-Gencell

"Biotechnologies have gained importance in the program (which is divided into four themes: methodology, medical research, agrochemical and chemical), and have progressively become a significant part of the program. The RPR-Gencell position in gene therapy has induced a progressive change in BioAvenir's priorities in favour of gene therapy by raising the credibility of scientists working in this field". (Staropoli, 1998, p:19) The type of information required by government, industry and academia in this particular study case is given in Table 3.2. In this Triple Helix, collaboration was conducted in two different countries, thus there is a higher variety of types of information required for participants in the collaboration.

EXAMPLE 2: BRAZIL WITH SOFTEX-2000 (SOFTWARE INDUSTRY)[2]

"From the beginning of 1992 to December 1996, the Brazilian government conducted an industrial policy to support the software sector, called National Export Software Program also known as SOFTEX 2000. The role of SOFTEX 2000 was to establish and encourage industry-academia relations. The program was implemented and conducted by the National Research Council, a Brazilian Federal Government agency which supports scientific development. During the course of the program some computer science university departments and a large number of Brazilian software firms were active participants. It can thus be said that SOFTEX 2000 is a Triple-Helix model. Finally it is worth noting that the SOFTEX 2000 protocol itself recognizes the small size of Brazilian software industries and their difficulties in exporting. Despite the inviability of the target, a number of internal variables of the country indicate the possibility of rapid growth in software exports".(Prochink, 1998) Among these: (Prochink, 1998)

- "The size of the internal market is of paramount importance as it is this which permits the development of businesses as future exporters.
- Educational infrastructure in the software area.
- The structure of activities of SOFTEX-2000".

[2] This material is collected from Internet and no relevant page is available, see bibliography for a complete Internet address.

The framework of collaboration programs in SOFTEX-2000 is as follows: (Prochink, 1998) (figure 3.2)

- "The nuclei consists of the local government, the local software industry, the nearest universities and local government laboratories. These actors conduct collaborative work in developing software. The prime objectives are to boost export and to increase local technological capabilities.
- The setting up of the nuclei is based on factors such as: a good computer science department at the local university (in that nuclei) and a significant number of software businesses in that nuclei. Those local regions that fulfil the criteria will get financial support from the federal government. The support can be extensive, including in the form of tax-relief. Also some international giant in the software industry like IBM, gives some support.
- To make the co-ordination works as efficient as possible, a group of representatives from government, academia and industry is established in the nuclei. The nuclei are, therefore independent entities that are designed to promote, produce and commercialize softwares for export, using SOFTEX 2000 resources".

After the nuclei have been set up its activities will then be as follows: (Prochink, 1998)

- "Linking up the companies and nuclei to the National Research Network.
- Setting up software development laboratories in universities and/or companies.
- Awarding scholarship and contracting research studies.
- Elaboration of studies, software technology fairs, organizing seminars.
- Expanding offices in a foreign country, such as in Berlin, Germany to gear with the European software industry and in China.
- Increase the economy potential with greatest presence in the region, for example: in Juiz de Forra region, the proximity of two specialists in agricultural science has fostered the creation of specific software for this application.
- Cross-subsidy concept, for example: the Campina Grande pole is situated in a very poor region of Brazilian North East. This is offset by the fact that it enjoy a great amount of support from all government spheres, the state agency and a strong local university".

"What particularly stands out in SOFTEX-2000 is the innovative institutional set-up which has led to the creation of a highly collaborative work environment, congregating a very wide range of agents. This is reflected in the support found in various government agencies and the press, two other important positive actors for the success of the program. Equally important has been the contribution from the scientific and technological base installed in

Brazilian universities and the predisposition of the academic community to take part in the development of industry". (Prochink, 1998) The obstacles that existed during the implementation of the program include: (Prochink, 1998)

- "Small size of Brazilian firms.
- Insufficient technical dynamism among firms.
- Low level Brazilian technology in software and lack of sources.
- Preferential option too ambitious for exports.
- International market not attractive for local companies since local markets are more promising.
- Lack of data about companies participating.
- Absence of any evaluation of certain activities".

Table 3.3. lists the required type of information for the three category of participants in this Brazilian example. From Table 3.3 it can be concluded that each different participant requires a different type of information in the collaboration. The industry sector requires the type of information for solving the problems and access to get such information. From Table 3.3 it can be seen that the government requires the information about the needs of the industry in order to better support the industry towards national development. The university requires this type of information to help support the industry and in order to find a better place for their graduates, to get access to industry for funding and also to find new ways of teaching on the basis of industry's requirements. For this particular Brazilian example, the mechanism for information transaction required for all participants is one which can be computerized. This is best done through an Internet based integrated system. In fact the creation of this kind of system is part of the program SOFTEX-2000.

Table 3.3. Summary of required type of information in the Brazilian example.
Source: Author compiled from Prochnik (1998).

Government	Industry	University
Local Government: 1. Facility, equipment, human resources and expertise available to conduct software manufacturing from each software factory 2. Facility, equipment human resources and expertise available to conduct software R&D from Department of Electrical Engineering and Computer Science in each university 3. Facility, equipment human resources and expertise available to conduct software R&D from public labs. 4. Data from tax-office 5. Short term planning (what to do to convince society that a plan is underway and it's for real. Funding the initial step in the plan. Establishment of national goals to be pursued) 6. Data of existing companies in the field of software engineering, their products, geographical distribution Federal level: 1. Available fund for conducting research works in the field of software engineering from foreign countries, foreign based industries and international organization (UN,UNDB, World Bank etc); 2. Available co-operative works in the field of software engineering from foreign based R & D centres, universities and governments; 3. The detailed programs in software engineering projects conducted in 26 local governments	1. Business plan for industry-demands, production, delivery, revenues, financial-resources, location, trademark, investment, return on investment 2. Infrastructure: Hardware and software needs, networking, communication, plant, specific building needs, working environment 3. Human resources: Number of people, qualification and training 4. Funding: local government funding, venture capital, own investment, incentive from larger companies	1. Number of students from faculty of Electrical Engineering and Computer Science engaged in Software Engineering research 2. Available equipment and facilities 3. Number of professors, PhD and postgraduate students in the field of software engineering research

EXAMPLE 3: THE MANUFACTURING OF A LARGE ASTRONOMY TELESCOPE[3]

"The Canada-France-Hawaii (US) Telescope (CFHT) foundation was established in 1974, with France (CNRS, a Government agency) and Canada (NRC, a Government agency) each holding 42.5% ownership and the United States 15% holding reflecting the University of Hawaii's contribution to the building of the infrastructure". (Langford and Langford, 1997) The framework of collaboration is as follows: (Langford and Langford, 1997) (figure 3.3)

[3] This material is collected from Internet and no relevant page is available, see bibliography for a complete Internet address.

- "The Canadian consortium, led by Government Agency NRC, conducts collaborative works with Canadian industries, and Canadian Universities to contribute to the development of a large telescope for astronomy application at Mt.Kea in Hawaii (US). The Canadian consortium is responsible for building telescope control, mirror polishing and the telescope dome. The dome which was the single largest expense for Canada was made by the Canadian company, Coast Steel of Vancouver which has subsequently become the world leader in dome construction.
- Similar works are also conducted by France and a US consortium. The French consortium led by the Government agency, CNRS, organizes and supports collaborative works with both French industries and universities to design the telescope movement mechanism and instrumentation. The US part representatives by the University of Hawaii and local government (State of Hawaii) contribute in the building of infrastructures.
- The US, France and the Canadian participants in three sectors (government-academia and industry) can then utilize the telescope for beneficial purposes such as remote sensing, astronomy and other scientific applications. The other turn-over of the project is the industrial spin-over to US, Canadian and French business sectors".

"The telescope case is an example of Mega science development. With the increasing sophistication in technology, this will demand increasingly both complex large-scale facilities and complex well-managed collaborative programs to address the most rewarding issues. It is expected that in the near future the growth of Mega science will imply growth in Triple Helix relationship". (Langford and Langford, 1997) Table 3.4 lists the required types of information from government, industry and academia, in the collaboration. Again this collaboration has involved three different countries which means that a wider type of information is required. However for each category of participant (that is: either from government, industry or academia), compared to the previous two case studies, the requirement for category of type of information remain unchanged.

From Table 3.4, the industry requires all specific technical information to deal with technical problems in building the telescope. The university requires a similar type of information from industry also offering a solution to the problems, while the government requires all types of information from the industry sectors especially in regard to technical problem solving to better support the industry.

Table 3.4. Summary of required type of information in the Canadian example.
Source: Author compiled from Langford and Langford (1997)

Government	Industry	University
CNRS: 1. Detailed program for design and construction of Telescope and instrumentation; 2. Data relates to required equipment, facilities, and human resources for design and construction of telescope; 3. Data about industries, government labs and universities engaged in the projects. This include numbers of industries, government laboratories and universities, company profiles and work division among participants of the programs; 4. Progress reports from participants in the projects.	Detailed (particular) program in design and construction of telescope and instrumentation assigned to the (particular) industry	Detailed (particular) program in design and construction of telescope and instrumentation assigned to the (particular) R & D labs of university

EXAMPLE 4: THE AUSTRALIAN BROKEN HILL PTY. COMPANY

"The Broken Hill Pty has developed a wide range of links with universities, CSIRO and other government research agencies, private research institutes and international collaborators. These feed into all facets of BHP's basic, strategic and applied research. In addition, BHP places significant emphasis on the training of both under-and postgraduate students, who often progress to positions within either BHP Research and its affiliates". (Turpin et al, 1996b:p 44) The framework of collaboration in at BHP is as follows:

- "The BHP establishes a BHP research centre, which will conduct an extensive collaboration with Australian universities. The collaboration with universities is maintained through government supported CRC program, postgraduate and undergraduate training, funding professorial chairs, sponsoring numerous university's research projects, establishment of an Institute (Institute of Steel, University of Wollongong), providing scholarships for best student from universities who often progress to positions within BHP or its other affiliates, jointly supervising BHP employees enrolled for higher degrees, employing vacation students and maintaining international links with foreign universities.

- BHP Research also conducts collaborations with government research labs such as CSIRO in the form of contract in technical courses.
- The most important point in the BHP case is that this company has combined both the informal and formal mechanism for co-operation". (Turpin et al, 1996b, p:44)

Figure 3.4 depicts the framework of collaboration. Table 3.5 summarizes the type of information required by the three categories of participant. BHP as a large industry requires a high level of variety of technical types of information to deal with all problems.

Table 3.5. Summary of required type of information in Australian example.
Source: Author compiled from Turpin et al (1996b).

Government	Industry	University
1. The number of university and government laboratories engaged in contracts with BHP; 2. List of the programs (in wider extent) that are conducted by university and government laboratories for BHP	1. The facility, equipment and human resources from both universities and industries involved in contract with BHP; 2. Detailed progress report of conducted programs from both universities and industry	1. The facility, equipment and human resources required to conduct projects ordered by BHP; 2. The progress report of projects to be submitted to BHP

The university participant (UoW) can use this opportunity to gain access to more types of information, which could be beneficial in terms of solving BHP problems (so that it will give financial profit to the university) and open new dimensions for research being conducted at UoW. The same applies to the PSR organization in Australia such as the Commonwealth Scientific and Industry Research Organization (CSIRO).

In summary, the previous section has described some features of the Triple Helix type collaboration from different countries. It can be seen that, in general, the Triple Helix has worked and there has been a process of transaction of information is an important part of the Triple Helix collaboration. From the four examples described it can be concluded that in terms of information flow in the Triple Helix, there have been some differences. From the figures the direction of the information flows from participant to other participants is different for each example. This indicates the different role of participants in the collaboration from an information perspective. However the content of information required by each category of participant in some examples could be identical. Moreover several interesting remarks can be derived as follows:

1. There is a common need to have an information system in Triple Helix type of collaboration. This is required for all types of industries/technologies and fields of research/countries. This common need is for an information system that can accommodate a comprehensive, extensive and regularly updated database that should include all relevant information required for efficient co-operative work.
2. It is interesting to note that even the structure of the Triple Helix for each example is similar (that is: each example has partners from government, industry and university) .However, the process of information transaction seems to be different in terms of how this process is 'dominated'. For example in the Brazilian example, the government dominates the process of information transaction, while in the French example, it is industry that dominates. Thus from these examples it can be concluded that there is a correlation between the process of information transaction and the role of a particular participant in the collaboration. A participant may be considered as 'main participant' and this is the participant who dominates the process of information transaction.

From the previous examples, the most important type of information required by each category of participant can generally be described as follows:

1. The university requires (in all cases) that the type of information relates to: the number of human resources and expertises involved in the collaboration work and also facilities and required equipment to conduct collaboration works. The other type of information required for all universities in order to participate in collaboration works is the detailed program assigned to the university including the funding allocated to the university, schedules and outcomes.
2. In general the industry needs the following type of information: the facilities, equipment, human resources and expertises from several universities and public labs engaged in collaboration works. Furthermore industry requires information about the business plan for a particular company (demands, productions, deliveries, revenues, financial resources including cost-sharing with partners/collaborators, locations of alliances in collaboration works, trademarks and related issues, investments and return of investment) regularly updated, progress reports from both universities and government labs and also other collaborators involved in the collaboration works.
3. The following types of information are those most required by government: the number of universities and industries engaged in collaboration works, the type of conducted collaboration works and the available fund sources to support the collaboration works. Furthermore the government is also responsible for gathering information about international market, opportunities, specific demands and also information about the situation in their own country such as: an existing company for particular product, service and process, potential for exports, existing products, services and process, and also geographical distribution of companies.

3.4. CONCLUSIONS

This chapter has described the roles of information and communication in the innovation process. It has also extended the discussion by taking several case studies. The chapter has explained that the important role of information is well understood in the innovation process. Innovation itself is basically the skill and process of mixing several bits of information and arranging them in a new pattern. Collaboration can help to achieve such a goal.

This chapter has shown that competence in innovation is largely determined by the skill available to conduct such an effort in an efficient and well co-ordinated way. In the process of innovation, information is the main ingredient. Several conditions have to be fulfilled in order to create a conducive environment for innovation from an information perspective. First of all is timeliness, information has to arrive whenever it is required. Second is readiness, when information arrives, the surrounding environment has to be ready to accept such information. Only when these requirements can be fulfilled, can information be useful for innovation.

Third is the channel of information transaction: the way this information can be brought to the place or can be created at a particular place are important in the innovation process. This is what is called the flow of information. A conducive environment for innovation requires a total freedom for this flow of information.

Fourth is the accessibility: the need for each player (in the innovation process) to have access to accurate information at any required time is also important for a conducive environment for innovation. The literature has concluded that most information required for change comes from outside the organization. This is another important consideration in the need to conduct collaboration for the creation of innovation.

The discussion has been focused on the process of innovation within the web of collaboration where 'Mode II Knowledge Production' and 'Triple Helix' arrangements have taken place. The examples taken from the literature covering different countries. These have proven the important role of both information and the mechanism of information exchange. The analyses of the case studies have concluded three following important points:

1. *Firstly*, there are some types of information, which are important to the entire collaborative process.
2. *Secondly*, these types of information could be different in regard to the specific country.
3. *Thirdly*, there is a common need for a particular type of information for each participant in the collaboration for innovation.

The government/public sector requires the type of information that relates to the activity conducted by both university and industry participants. The industry requires the type of information that relates to the technical type of information to solve problems they encounter in the innovation process. The university requires the type of information that relates to projects conducted by industry in order to market their research results. It is thus basically a mixture of technical and marketing types of information.

It is interesting to note that, in each of the collaborations studied there exists a major participant, who 'dominates' the process of information transaction in the entire collaboration. Given that the main commodity in the process of collaboration is information transaction, the information system is obviously in a position to play an important role in the success or possible failure of the collaboration. This also increases the need for each participant to have an integrated information system to enable a better information transaction.

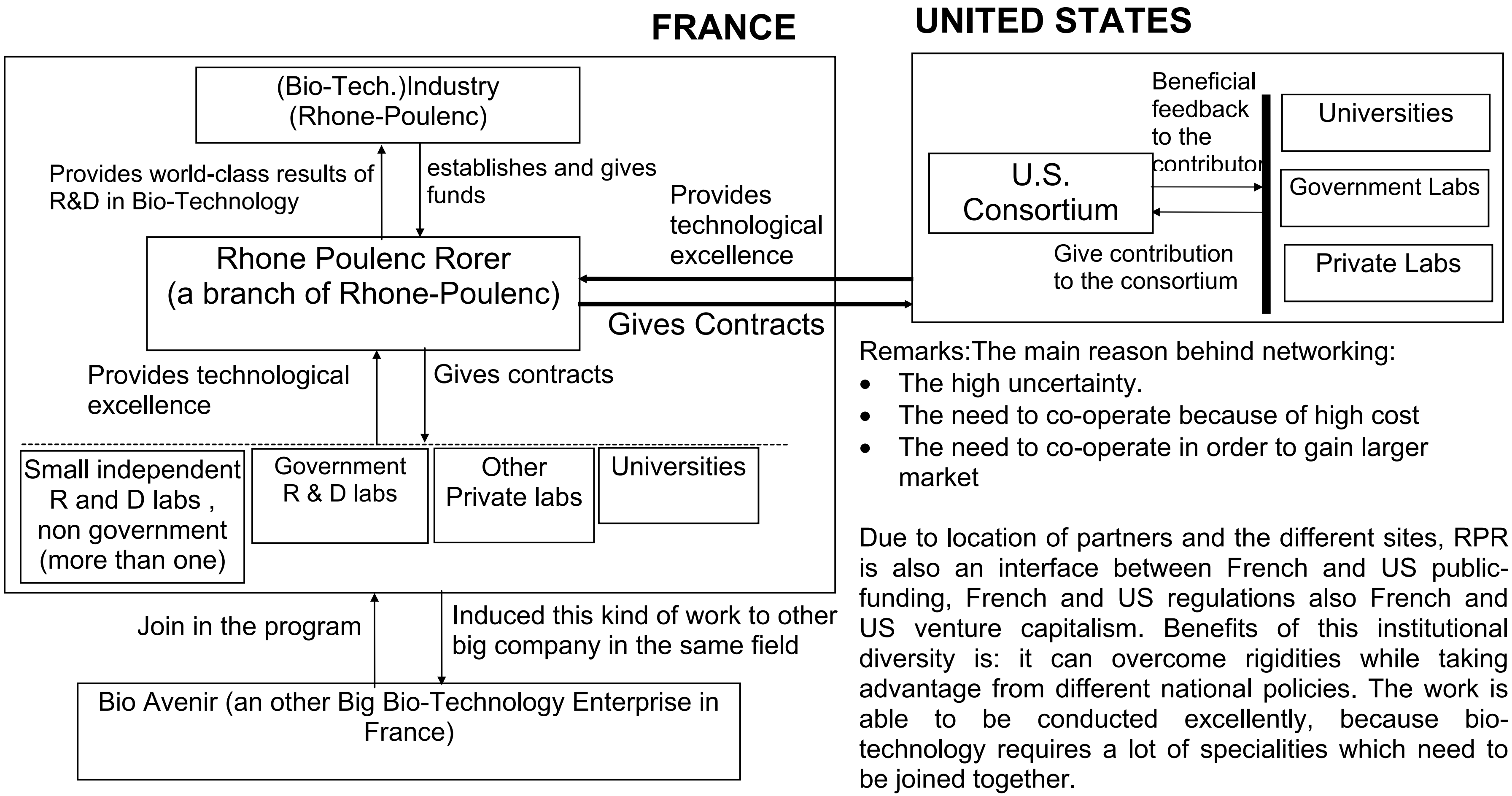

Figure 3.1. The type of information being exchanged in French example.
Source: Author, compiled from Staropoli (1998).

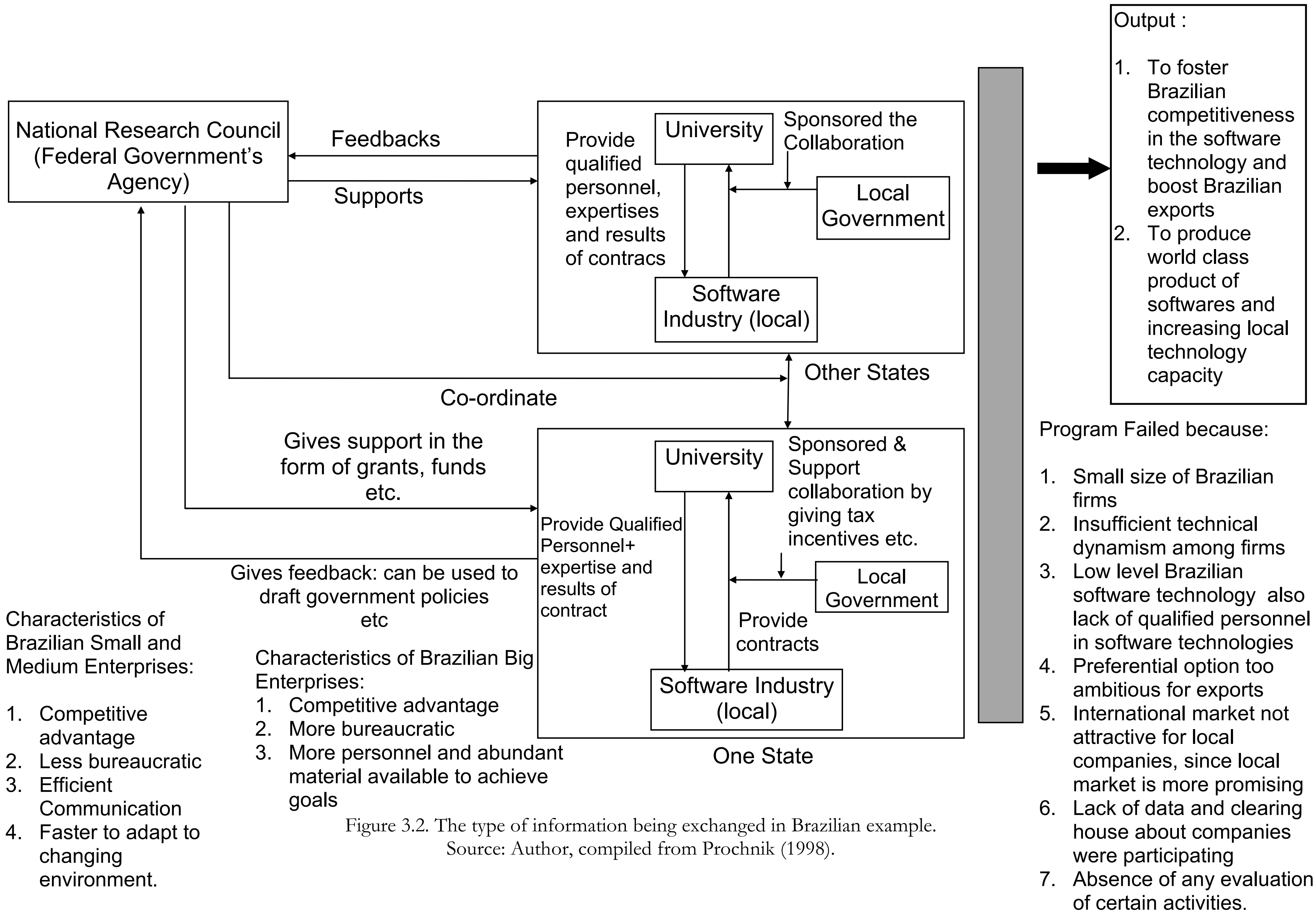

Figure 3.2. The type of information being exchanged in Brazilian example.
Source: Author, compiled from Prochnik (1998).

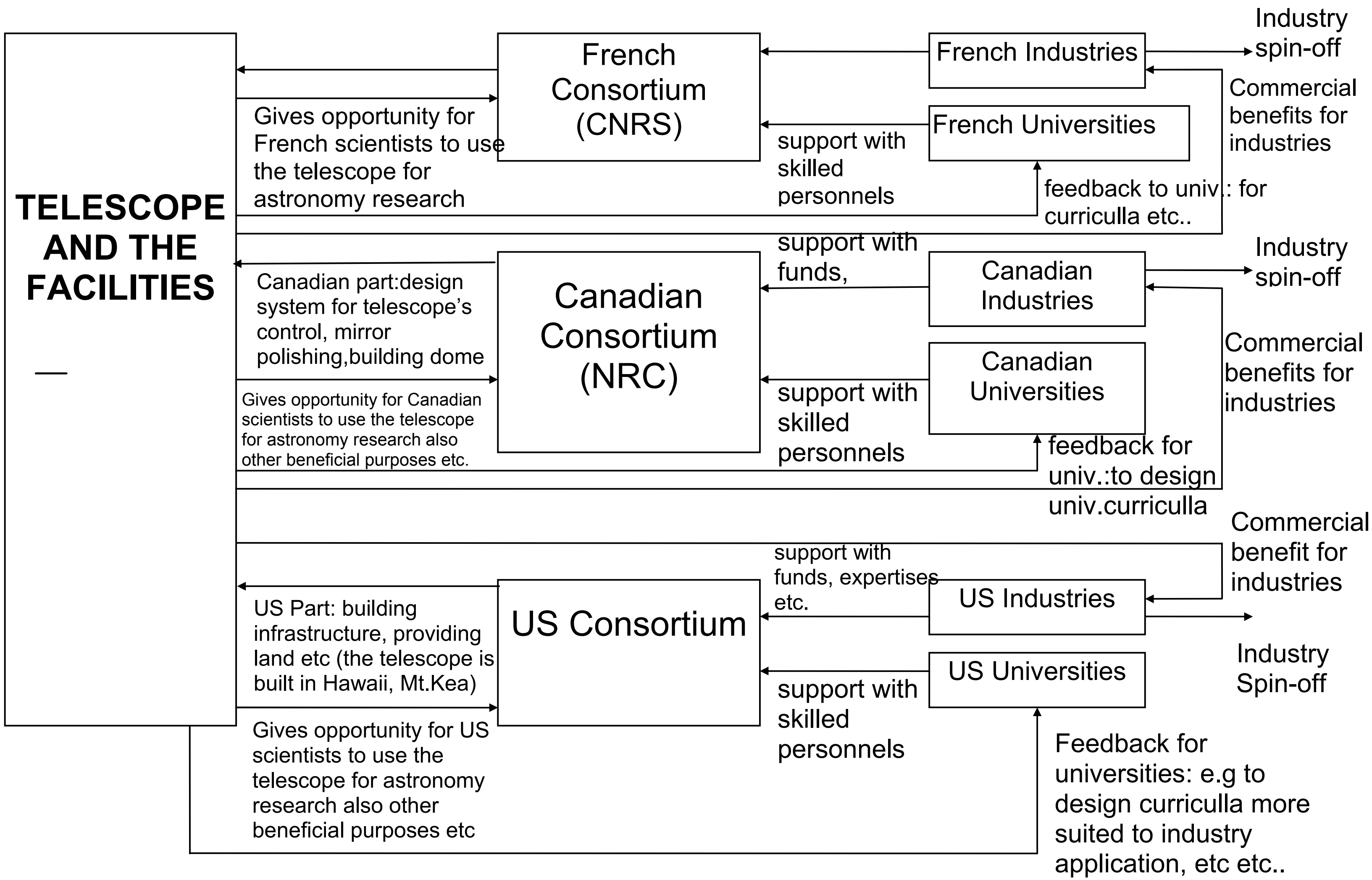

Figure 3.3. The type of information being exchanged in Canadian example.
Source: Author, compiled from Langford & Langford (1997).

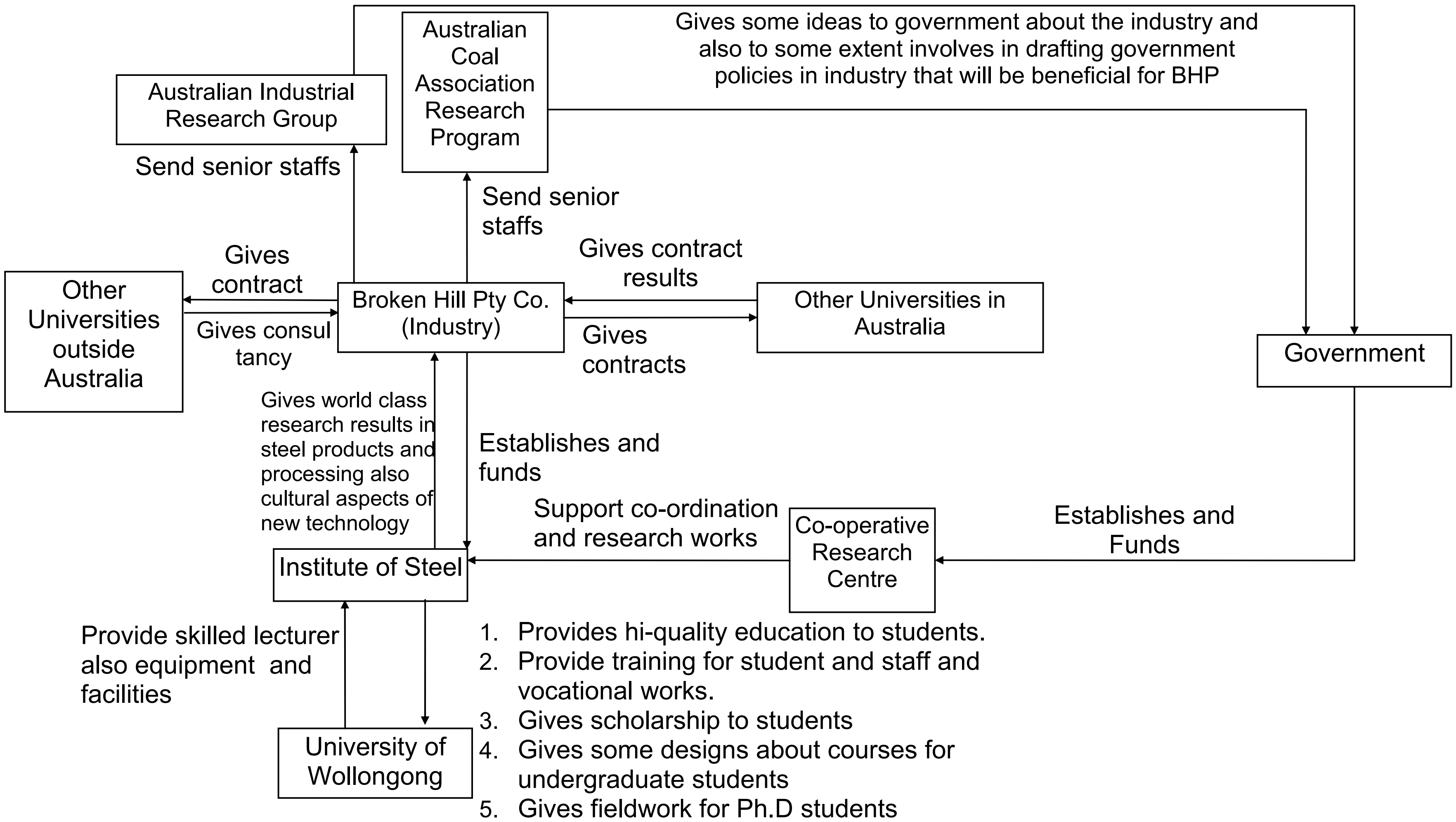

Figure 3.4. The type of information being exchanged in Australian example.
Source:Author, compiled from Turpin et al (1996b).

CHAPTER 4. INNOVATION, COLLABORATION AND INFORMATION SYSTEM IN THE AUSTRALIAN CONTEXT

This chapter discusses the innovation, collaboration, and information system in the Australian context especially the Co-operative Research Centre (CRC). Based on the theories addressed in previous chapters, the information system has a special role in allowing the collaboration under Mode II to emerge and later to operate. The discussion on these topics is necessary, given that the model which will be developed in Chapter 5 is based on the information perspective. Moreover, the case study to test the model will take Australian Co-operative Research Centres as the object of analysis. Thus section 4.1 discusses the CRC in general. Section 4.2 presents some examples of the Australian government information system that supports innovation especially in industry and the business sectors in Australia. Section 4.3 gives some conclusions.

4.1. THE AUSTRALIAN CO-OPERATIVE RESEARCH CENTRE PROGRAM

This Australian Co-operative Research Centre program (later will be denoted as CRC) was established in May 1990, as a result of the proposal of the chief scientist, Ralph O. Slatyer, to establish a program of collaborative and co-operative research, which would bring universities, CSIRO, research institutes, industry and key organizations together.

From theoretical perspective the co-operative research is necessary to improve the rate of knowledge accumulation of the involving participants. Michael Gibbons et al illustrate this point as follows,

> "The accumulation of capital, insofar as it involves the creation of technological knowledge, takes place inside a firm, but the rate of that accumulation is related to the extent to which the firm has access to knowledge generated by others. This in turn, causes firms to seek a collaborative relationship of many kinds; to form consortia (for example: SEMATECH[1]), to join international programs (such as EUREKA[2]) and to try, by dint of their recognized competence to join networks of various kinds". (Gibbons et al, 1994:p 59)

The following quote from the same scholars indicates that an institution that function as a broker is necessary and the role of such institution is not only to facilitate the relationship and to support the communication among the participants in the collaboration, but also other important functions,

> "Generally, when knowledge production is carried out in a diversity of contexts of application, new skills in configuring knowledge resources, which is called brokering becomes crucial. The brokering skill is needed to link the problem solvers and the problem identifiers and to assemble the required combination of resources, both human and physical. This is a matter not only for facilitating relationship between group of researchers but also of making easier communications with innovators, regulators, venture capitalists, etc". (Gibbons et al, 1994:p 162)

Furthermore Gibbons et al indicate that the task of brokering requires some special skills,

> "…….brokering will demand exceptional skills because the individuals involved in the innovation process will come from many different institutions and organizations, they will often be dispersed geographically and may only be able to work on a problem or project part time." (Gibbons et al, 1994:p 162)

From theoretical perspective the broker should be from the government. This is explained by Gibbons et.al in the following quote,

> "……this brokering should be for *government*, alone or in co-operation with others, or some of their agencies, to function *as honest brokers*. Governments are a logical choice for this role because much of the brokering is likely to involve other governments or

[1] SEMATECH, stands for SEMiconductor MAnufacturing TECHnology, is a collaborative industry-government manufacturing venture sponsored by government in the United States. This program has the goal of restoring the U.S. semiconductor industry's ability to compete against the Japanese in semiconductor manufacturing.
Source : http://www.sematech.org/public/corporate/history/1986.htm#may retrieved at December 20, 2000.

[2] EUREKA is a pan-European framework for research and development cooperation through which industry and research organisations from 26 European countries and the European Union (EU) develop and exploit the technologies crucial to global competitiveness and a better quality of life. The European Union has been a member of EUREKA since its inception in 1985. Source: http://www.cordis.lu/fp5/eureka.htm retrieved at December 20, 2000.

> their agencies. Brokering is necessary because in distributed knowledge production more actors that are not all technical experts, are involved". (Gibbons et al, 1994:p 162, emphasis added)

In Australia the need to establish such a broker (as CRC) has a fundamental reason as indicated by Tegart as follows:

> "….. government, industry and university relationship. Universities and industry, up to now relatively separate and distinct institutional spheres, are assuming tasks that were formerly largely the province of the other. Thus universities are looking to commercialize research while industry is looking to provide training and to contract out its research. The role of government in relation to these two spheres is changing in apparently contradictory directions. Governments are offering incentives, on the one hand, and pressing academic institutions, on the other, to go beyond performing the traditional functions of cultural memory, education and research, and make a more direct contribution to wealth creation. Governments are also shifting their relationships to industry, becoming both more and less involved. …. The cumulative result of these three *paradigm shifts* is that there is a complex interaction between government, industry and universities driven by the need for wealth creation, the need to maintain competitiveness on a global scale and the need to ensure optimum linkages and outcomes between research and commercialization". (Tegart, 1996, ATSE Focus, No.92, May-June 1996, emphasis added)

Based on the previous quotes it can be concluded that Australian CRC is to function as broker institution as indicated by Gibbons et.al. This thus clearly reveals that CRC is a good example of Mode II Knowledge Production. From theoretical perspective the establishment of CRC can be very conducive to increase the accumulation of knowledge which later can be helpful in the creation of innovation. Moreover CRC would be expected as a manifestation of paradigm shift of government's role in its relationship to industries and universities. The description of CRC is to strengthen the linkages between research and industry as given in the following quote,

> "The program emphasizes the importance of developing internationally competitive industry sectors. … The structure of the program provides a powerful mechanism for achieving that objective, principally through the contractual arrangements which, establish each CRC, and link the CRC to the Commonwealth, and the objectives of the government. *CRCs strengthen collaborative links between researchers and industry and other research users in order to capture the benefits of research in natural sciences and engineering more*

> *effectively*. Furthermore, CRCs increase efficiency of research and research training through effective collaboration of teams of top researchers from a variety of organizations.".(http://www.dist.gov.au/crc/faqs/index.html retrieved at December 10, 1999, emphasis added)

The CRC program covers a range of topic from both natural science and engineering as given in the following quote,

> "The established CRCs cover many areas of natural science and engineering, manufacturing technology, information and communications technology, mining, and energy, agriculture and rural based manufacturing, environment and medical science and technology." http://www.dist.gov.au/crc/faqs/index.html retrieved at December 10, 1999.)

In detail, the concept underlying the CRC program is given in the following quote:

- "To create a system of world class applications-oriented research centres by linking together outstanding research groups from public and private sectors".
- "To enable each participating group to retain its separate institutional affiliation, but each centre to constitute a collaborative integrated research team".
- "To focus the research on challenging research fields and areas which underpin existing or emerging industry sectors".
- "To co-locate the groups participating in each centre, wherever possible, to promote effective co-operation and to enable expensive facilities to be used efficiently and without unnecessary duplication".
- "To locate the centres on or adjacent to university campuses wherever possible, so as to encourage precinct development around universities and enable the centres to contribute as fully as possible to the strengthening of educational programs".
- "To ensure that each centre is led by a director who would be an experienced and highly regarded researcher with appropriate management skills". (Slatyer, 1993, 122)

The CRC program is closely related to innovation, for the establishment of CRC itself is to solve the weaknesses in the Australian innovation systems, in particular:

- "The fragmentation among research organizations and the lack of critical mass."
- "The impediments to interaction between industry and user research generally and the public sector research organizations."
- "The limited growth of major Australian enterprises in new technology and trade intensive sectors."
- "The challenges for appropriate research support and management for the primary industry sectors."

- "The development of links to leading international centres of research". (Mercer and Stocker, 1998, p: 11)

From the above quote it is expected that CRC can increase the innovation capability of Australian industry, university and public sector research agency. This is achieved by maximizing the interaction between industry, university, public sector research agency and making better use of research resources through the sharing of facilities and equipment. CRC enables an interactive collaboration between industry and university with which enables the university (as well as PSR) to conduct research based on the need from the industry. This is obviously close to the concept of 'production of knowledge in the context of application' as suggested by Gibbons et.al.

Table 4.1 summarizes the main objectives of the CRC Program[3]. In Table 4.2 the key characteristics of CRC are given. Central to achieving the CRC's objectives (Table 4.1) is the implementation of high quality management in research, development, education, and training, particularly by ensuring effective strategic planning, human resource management, equal opportunity, training and evaluation by the Centres[4].

Table 4.1 (I). The objectives of Australian CRC. Continued on Table 4.1 (II).

[3] Ibid.
[4] http://www.dist.gov.au/crc/faqs/program.html, retrieved at December 10, 2000.

Source: http://www.dist.gov.au/crc/faqs/index.html retrieved at December 10, 1999.

Goal	**Specific Objectives and Strategies**
Contribute to economic and social development	1. Support long term high quality science and technology research. 2. Selected by expert panels on the basis of open applications.
Strengthen education and training	1. Support postgraduate students integrated into CRC research program. 2. Involve researchers from government and users in student supervision. 3. Support industry training activities to disseminate new knowledge.
Governance	Each CRC has a Director reporting to a Board with an independent chair.
Raise the effectiveness of R & D	1. Require users to contribute to the support of CRC research. 2. Involve users in the management and activities of CRC 3. Strengthen the management of R & D through the role of CRC Boards. 4. Improve the mobility of graduates and research personnel.
Raise the efficiency of R & D	1. Stimulate co-operation among public sector research providers to achieve synergies and critical mass. 2. Strengthen accountability through performance reviews. 3. Enable sharing of major facilities and equipment
Sectors	Manufacturing, Information and Communication Technology, Mining, Energy, Health and Pharmaceuticals, Environment, Agribusiness.

Table 4.1 (II). The objectives of Australian CRC
Source: http://www.dist.gov.au/crc/faqs/index.html retrieved at December 10, 1999.

Goal	Specific Objectives and Strategies
Selection	CRCs are selected by The Minister on the advice of the CRC Committee, which in turn is advised by Expert Panels. Selection is through a competitive process based on specific criteria.
Activities	1. Research – usually with a portfolio from short term applied to long term strategic/basic. 2. Education – post graduate research. 3. Training – user oriented programs to raise awareness and transfer knowledge.
Core Participation: Research and Education Organisations	1. Core participants are those organizations who have entered into seven year contracts to support and collaborate in the CRC. 2. All CRCs involve universities (often more than one and usually more than one department in a university); they also involve, a Commonwealth government research organisation (such as CSIRO, DSTO, AIMS, ANSTO and AGSO) and in some cases other research organizations such as state government departments and independent research organizations.
Other participation	Several CRCs have associated member programs in order to facilitate links with a wider range of potential users.

The CRC works better than the ordinary CSIRO program[5] because the CSIRO program and other ordinary research programs are based on priorities set up by CSIRO staff. Therefore there is no involvement from the research users during the course of the program. The CRC program works differently, the users are involved from the inception of the program until the end of the program and to some extent allow the users to have dominant roles in the program[6]. Thus from this perspective the CRC program is superior compared to the ordinary research program.

[5] Interview with Dr. John Boyd, member of CRC Committee, Department for Industry, Science and Tourism, October 22, 1999.
[6] Ibid.

Table 4.2. What is a CRC ?
(Source: http://www.dist.gov.au/crc/faqs/index.html retrieved at December 10, 1999).

Item	Explanation
Core Participation : Users	1. CRCs are not contract research organizations. 2. Users who are core participants contribute to the resources of a CRC and participate in all aspects of management. 3. Users may be government departments, utilities, Government Business Enterprise, Industry Associations or Private companies.
Funding[7]	The CRC program grant provides from 16% to 49% of the resources of a CRC. Participants provide cash and in kind contributions. The average size of the budget of a CRC is $ 6.3 million per annum. CRC program funds can be used flexibly for salaries, research costs and capital items, but are provided for an agreed work program and expenditure is monitored.
Performance evaluation and review	CRCs must enter into a contractual agreement with the Commonwealth, which identifies performance milestones and indicators. Performance is monitored by the CRC secretariat on the basis of these indicators and financial reports. Performance is reviewed by the CRC committee through expert-panels in the third and fifth year.
Duration	CRCs are established under contracts that generally run for 7 (seven) years. Established CRCs may compete with new applicants for further funding
Infrastructure	Most of the physical infrastructure of a CRC (offices, research facilities, and equipment) is provided by the participants as a part of their material contribution to the CRCs resources. In some cases additional facilities and equipment are purchased.
Location	Most CRCs have one or more nodes, in addition to a central location (usually in a university), depending on the number and location of participants.
International links	Participation by overseas companies and research organizations is possible, provided the arrangement clearly provides benefits to Australia, is within the mandate of the core participants, and is approved by the CRC Committee

After seventh year of its operation, a joint review conducted for the Minister for Industry, Science and Tourism, Mr. John Moore and Minister for Finance and Administration, Mr. John Fahey, in 1997, concluded the following positive facts on the CRC program:

- "The CRC program plays an important role in the Australian innovation system".

[7] See appendix 5 for conditions under which funding is renewed.

- "The CRC program has strong and widespread support in addressing important national objectives and developing valuable new approaches to research management and commercialisation and it is seen to be significant beyond its activities."
- "There is no evidence of a diminution over time in the quality of new centres.
- "CRCs have contributed significantly to enhancing interaction with international research organizations."
- "The CRC program represents effective investment of public money in R & D."
- "There are examples of significant technological developments and of technology transfer in many sectors, and some outstanding examples of the commercial benefits of CRC research, but the major impacts of the program will not be evident for some years."
- "One of the most important benefits of the program is already evident in the changed attitudes and perspective within industry and research organizations."
- "Commercialisation is a heterogeneous process and not simply the transfer of intellectual property to the private sector. It can be improved by increasing user involvement in CRCs and by strengthening the governance of CRCs and the program."
- "The program's funding is no more to be regarded as a "business assistance" than is the funding of universities and CSIRO."
- "The criticisms in recent Mortimer Report[8] "Going for Growth, Business Programs for Investment, Innovation and Export" are ill founded. Concerns about excessive levels of private benefits are over-stated."
- "Commonwealth core funding encourages collaboration in a CRC and forms the glue that unites the participants."
- "Some CRCs will achieve self-funding and most a greater degree of self funding before exiting from the program. However, the proposals for new valuable centres will continue to emerge and the overall program will remain substantially dependent on commonwealth funding."
- "The possibility that the royalty income from intellectual property generated by CRC might provide a revenue stream sufficient to fund the CRC program, and hence displace the need for on-going commonwealth funding, is remote". (Mercer and Stocker, 1998, p:iii)

"The CRC program is a bridging mechanism in the innovation system, rather than another contract research mechanism to provide subsidized research to industry. However, it extends beyond this. Other roles of the program are as a mechanism for[9]:

[8] On 22 November 1996, The Minister for Industry, Science, and Tourism announced a comprehensive Review of Business Programs. This Report was titled "Going for Growth" but is also well known as Mortimer Report, (named after its program leader: Mr. David A. Mortimer). This report strongly criticized the CRC program, questioned the value of the program, and recommended the closing down of the CRC program. According to this report, the CRC program just funds institutions (i.e the providers of research) rather than research activities themselves. This is inconsistent with the Review's program design principles, in particular that funds should be directed at the activity rather than institutions or providers. Source: http://www.dist.gov.au/events/mortimer/chapter1.html, retrieved at December 12, 1999.

[9] Ibid.

- "Focusing substantial and high-level research resources on issues of national importance in order to achieve critical mass".
- "Research management that entails accountability with considerable flexibility".
- "Direction setting and evaluation that involves a range of users and research providers".
- "Developing industry-aware-postgraduates".
- "Changing the culture and capabilities of users and research providers in Australia".
- "Developing focus points from which substantial international links can develop".
- "Fostering collaboration and networking among research agencies".
- "Providing stable funding to enable research of significant magnitude."
- "Enhancing the quality and relevance of education. "
- "Training industry aware researchers and researcher managers." (Mercer and Stocker, 1998, p:12)

Because CRCs are changing the way in which research is undertaken in Australia and because truly co-operative research can be more difficult as well as more rewarding, it is inevitable that not all CRC will fill all the objectives listed in Table 4.1. Difficulties seem most likely to arise for reasons such as the following:

- "The continuing challenge of co-operative research places particular stresses on management. Not all directors and leaders of the various research programs will necessary have the skills to ensure that the participants, as groups and as individuals, will continue to work well together. This is likely the most pronounced when a CRC has several nodes of activity, each of which is staffed primarily with researchers from only one institution. Under these circumstances, the benefits of involvement with the centre are likely to be less evident and the task of developing and maintaining joint projects more difficult".
- "Failure of the parent institutions to remain strongly committed to the program and to the centres with which they are involved. Such a loss of commitment would make it difficult for their staff to balance their loyalties to both centres and to their institutions. A loss of commitment by the parent institution could also be reflected in a tendency to divert agreed resources away from the centres or to reduce access to facilities by centre researchers from other institutions".
- "Failure of those participants who are research users to play an active and constructive role in the planning and the implementation of the centre's program. This is most likely to arise when the research users have not undertaken R & D themselves or are not sophisticated users of research information. In such cases they are less likely to be aware that the greatest benefit from their involvement in a CRC will probably be from access to the body of information and skills contained with it, rather than to particular items of intellectual property. To derive this benefit, they cannot be passive participants but must build their own levels of skills and experience so that they can interact effectively. Hopefully, as each CRC's program is implemented, all research users will rapidly become

> aware of the benefits of active co-operation but, to the degree that this does not occur, one of the important objectives of a CRC would not be achieved".
> (Slatyer, 1993, p:122)

In spite of some possible potential problems, the report provided Mercer and Stocker of evaluation on CRC concludes that,

> "….the CRC program, is widely seen as the most successful mechanism in Australia for linking users with research organizations. All countries have sought to develop mechanisms for this purpose but there is no evidence that would suggest that any other country's experience provides institutional or program models that would offer advantages over the CRC program…. The CRC program also complements the work of the universities, CSIRO and several other PSR Agencies. This program clearly stimulates greater industry spending on R & D and greater industry involvement in guiding R & D in the public sector". (Mercer and Stocker, 1998, p:12)

The previous quote proves that CRC operation has been successful in providing linkages between university, industry and public sector research agencies. Moreover CRC resembles many aspects of Mode-II Knowledge Production, thus taking CRC as case study would be quite accurate to examine the application of Mode-II Knowledge Production into real practices.

The next section 4.2 describes some examples of the government information system to support innovation in Australia.

4.2. SOME EXAMPLES OF THE GOVERNMENT INFORMATION SYSTEM TO SUPPORT INNOVATION[10].

This section describes the government information system for supporting innovation especially in business and industry sectors. This section is necessary given that industry (as previously mentioned) is the main target of the CRC program. The reasons for taking the Department of Industry Science and Tourism (DIST) as a point of consideration is because, at the time of writing (2001) this department had responsibility for advising the government and portfolio ministers on industry, science and tourism issues and delivering programs to manufacturing, services, tourism, small business and consumer affairs, and science and technology sectors. It is also the central point of contact for industry, unions, other Commonwealth departments, and State and Territory Governments on these issues, so this means that DIST is one of the government agencies which is directly engaged in Science and Technology development. Moreover, this department had a special responsibility in administering the CRC program, although the CRC program was arguably established within the Prime Minister's Department.

This ministry comprised those Commonwealth agencies with responsibility for developing, implementing and administering policies and programs designed to[11]:

- increase the competitiveness and internationalization of Australian manufacturing and service industries including tourism;
- develop Australia's science and technology capabilities and infrastructure;
- promote balance between consumer and business interests within a fair and competitive marketplace.

[10] http://www.dist.gov.au retrieved at June 18, 1998.
[11] Ibid.

This section describes the usage of the information system in DIST for supporting the industry and business sectors. The DIST's Office of AusIndustry, in conjunction with State and Territory Governments and State Offices, is directly involved in the delivery of the R&D Start Program, the R&D Tax Concession Program, the Enterprise Development Program and the Business Networks Program. It is also responsible for national AusIndustry marketing and the Business Information Service. The list of some examples for the use of information systems supporting innovation in the industry and business sectors is given the following Table 4.3. This information was taken from publication of DIST from the Internet, http://www.dist.gov.au which was retrieved on June 18, 1998.

Table 4.3. Some examples of the information system promoted by DIST to support innovation in Australian business and industry sectors. Source: Author, compiled from DIST website.

Name of Information System	The Main Purpose of the Information System
BNP WWW Sites and BNP Matching Service	As a network broker for posting and seeking business network opportunities
Business Information	Information of government and industry programs and services
The Business Licence Information Service (BLIS)	The Business Licence Information Service (BLIS) is a free one-stop information service for all licences and permits that businesses are required to have in order to operate
The BizLink	BizLink is an innovative computer-based information service, which provides Australian firms and their advisers with access to critical business information. In addition, there is also valuable information on intellectual property protection issues
The New National Business Information Service	To enhance the BLIS and BizLink capabilities
The continuing usage of web browser and networking for supporting R & D activities.	To support Australian Industry in the diffusion of Internet Technology
Information Technology On-line	An on-line technology to support SME
Multimedia Forums	To support collaboration from a range of media and information technology disciplines in order to develop world-class multimedia products and services
Multimedia Networking	To promote networking in the multimedia industry, and assisted firms in order to develop skills and achieve best practice
The Business Equity Information Service (BEIS)	To reduce the high search and transaction costs

The examples have shown a well-varied use of the information system by government to support industry and business activities in Australia. From these examples it may be concluded that to some extent, the usage of this system to support R & D activity, including its relation to business, has been under constant consideration of the DIST. Thus the government has been working to make the business and industry sectors become aware of the existence of such information systems and how these systems can be beneficial to the conduct of business. Government has shown an interest in building such an extensive information system to really connect the users and suppliers of knowledge. The existing information system infrastructure in Australia enhances such combination of information by integrating the players in the innovation system in networks where all information can be transmitted in a faster and easier way.

An example is being able to get access to relevant databases for those players in the innovation system. These databases are available on-line and are updated regularly. In this way, the business sector may tap the information and then can give inputs to the researchers so that the research results are directly applicable to the real problems faced by the business sectors. This also applies to the industry sectors. Such a situation is very supportive for the realization of Mode II Knowledge Production, because an exchange of information is much easier and faster and allows for different entities to take part in the collaborative process to conduct trans-disciplinary research.

The CRC program addressed in the previous section may get some benefits from the existence of such an information system. The CRC can no longer depend on proximity for all researchers are basically well connected on-line through this system. Moreover with its high level of trans-disciplinary context of activity, the already available information system infrastructure provides a better and easier understanding to anticipate several problems in trans-disciplinary research work.

One of the problems at CRC raised in the previous section is the need to maintain a strong commitment for each participant to remain in the collaborative research partnership at CRC. By using this information system it is expected that such a problem may well be solved or at least that ready communication will assist their resolution. The availability of this information system makes understanding of the problem much easier due to faster information exchange.

This information system also provides a good platform to anticipate all problems which may arise in the management and administration of CRC. Monitoring and evaluation problems can also be anticipated for the information system can provide online access and monitoring of nearly all kind of activities from the start to the completion of the program. The information system also provides the possibility of being able to break down the monitoring and evaluation on a more detailed basis (such as daily or weekly).

Thus the CRC and the existence of a wide array of information systems and infrastructure in Australia, and government interest to develop, distribute, and diffuse this system are in mutual symbiosis. The CRC program combined with the existence of the information infrastructure creates a very conducive situation for innovation. Furthermore, the existence of such an extensive information system also enables the application of the Triple Helix in analysing the process of operation in the Australian innovation system while again strengthening the fact that information systems have become a significant component in the Australian innovation system. The Triple Helix requires a situation where universities-industry and government agencies are working in collaboration with a high level of flexibility and ability to change the roles amongst themselves. This kind of situation is much easier to conduct when there is an infra structure of information systems available and in particular the codification of information can more easily exchanged.

Thus the existence of this information system infrastructure is supportive for both the operation of CRC and the analysing of the operation of CRC by using the Triple Helix. The development of this new theory will be introduced in the next chapter. Moreover, interest by the Australian government in expanding the information system infrastructure also indicates that research about the role of information systems supporting government in R & D collaboration is important and necessary.

4.3. CONCLUSIONS

The CRC is a collaborative research partnership, which aims to conduct research in the context of application especially for Australian industry. This collaborative research partnership is aimed at boosting capacity in R & D in order to make industry more competitive in the world market and to increase awareness of the benefit of participating in research with an industry partner, the university and other research providers. The objectives of the CRC program can be summarized as the ability to maximize the capture of benefits of research through the development of enhanced co-operative linkages between industry, as research users and research providers in both the public and the private sector. This is achieved by cleverly integrating research providers and research users in a single entity and the research programs being set up on the basis of the problems faced by the industry partners.

Thus the CRC concept clearly reflects the application of Mode II in an Australian context, because there is an imperative to make sure that the result of the research conducted in this program is ready to be embraced by industry. The Federal Government sponsors the CRC program, and it brings together researchers from the both public and private sectors with the users of the research for up to seven years. The CRC program has been working very well, reflecting the fact that Mode II is flourishing in Australia. This chapter has presented evidence to show that CRC has generated some benefits for industry and has contributed some important advancement in R & D, especially in regard to the innovation capability of knowledge producers and commercialization of research results. The CRC has produced public good outcomes, such as better prepared university graduates, better research managers with good views about industry needs, and the development of research cultures and networks among industries. The CRC model has been successful in helping industries to become more competitive. This program has been reviewed and several successes and new breakthroughs in the field of R & D have been recorded. The future of the CRC program has been the subject of a strategic planning workshop by government and industry. It has been concluded that CRC is a very effective operation, a conclusion which reveals the success of using Mode II in making industry become more innovative and successful in dealing with the highly dynamic, current world economy. The characteristics of CRC, which reflects Mode II and its ability for making industry become more innovative, have been discussed in this chapter.

This chapter has also presented some examples of the usage of government promoted information systems to support the business and industry sector. From these examples it has been found that government is very supportive and has a very positive attitude in employing this system to these sectors. The government has allowed information systems to become a platform to enable online, fast and easy communication and information exchange for the industry sector (and business sectors) which are the players in the innovation system and main target of the CRC. Moreover in this way, government has also increased awareness of the players in the innovation system about the benefits of using such a system in their activities. It can be concluded, to some extent, that players in the Australian innovation system are well connected with the support of this kind of information system. Most importantly, the government has realized that there is a need to link the players in the innovation system by using this information system, making them become more computerized, well connected and better integrated. The existence of this information system, which connects nearly all players in the national innovation system, will allow the execution of collaboration in the Mode II. In relation to the CRC, it may be concluded, that to some extent, the Australian 'infrastructure' is already conducive to creating a situation which is suitable for CRC operation, even where CRC participants come from different types of organizations. The information system infrastructure introduced in this chapter may also help support and solve some possible problems encountered at CRC such as management and administration problems.

It can be concluded from this discussion that the CRC program has been successful in supporting the players in the innovation system in Australia and moreover the information system for R & D collaboration has been considered important by the government. Thus the

Australian innovation system is already connected by quite a comprehensive information system. Both factors combine to create a conducive situation for the development of a new model introduced in the next chapter.

CHAPTER 5. THE "NEWT" MODEL

This chapter discusses a new model of the role of information in collaborative R & D and is called "Newt" model. This model is a distillation of the author's own theories and ideas, and theories previously developed by von Hippel, Macdonald, Leydesdorff and Gibbons et al. More precisely the elements of the previous theories that have been taken for the construction of the "Newt" model are: (1) information theories of innovation developed by Macdonald; (2) sources of innovation theories developed by von Hippel; (3) the Triple-Helix metaphor introduced by Leydesdorff and Etzkowitz; and (4) the Mode II Knowledge Production theories introduced by Gibbons et al. As the model is an improvisation of Triple Helix model, the "Newt" name has been chosen. Newt is an acronym of NEW Triplehelix., thus **New T** or Newt. There is no specific reason for choosing 'Newt' rather than 'Newth' for New Triple Helix except that 'Newt' is supposed to be easier to spell out and to remember.

The organization of the chapter is as follows: section 5.1 presents an introduction to the "Newt" model. Section 5.2 explains in detail the construction of the "Newt" model. Section 5.3 discusses the CRC'style according to the "Newt" model. Section 5.4 introduces the concept of 'Information Mixing Pot' and in section 5.5 the research methodology used to test the model is explained. Finally some conclusions are given in section 5.6.

5.1. INTRODUCTION TO THE "NEWT" MODEL

Von Hippel theories of innovation emphasize the importance of considering all kinds of actors in the production process. The source of innovation can originate from any of these actors and there is thus a need to consider them as equally important in terms of their potential to become sources of innovation.

Mode II Knowledge Production stresses the coalescence of trans-disciplinary, economic and social contexts. There is an imperative to conducting trans-disciplinary research to make the research results more applicable for the users. The idea is to bring the user in the process and thus conducting the research work according to the user's requirements. This concept is proposed as a measure to anticipate the current new trend of globalization and as a new method to become more innovative and to make research more localized in the context of application, rather than as a 'free' research (Gibbons et al, 1994).

Normally, Mode II is based on a collaborative partnership of different participants in conducting of research work. These different participants usually have different backgrounds with their own different level of information repository and knowledge capacity. In this type of knowledge production, the locus of innovation (or new discovery) is no longer limited to a particular entity e.g: in research institute. In fact the innovation can be created anywhere, something which reinforces the von Hippel theory for the source of innovation.

The information system plays a crucial role in this context. Gibbons et al note that, "in terms of communication among scientists, the trans disciplinarity has been facilitated through the availability of modern information and communication technologies". (Gibbons et al, 1994, p:38) Moreover Gibbons et al also note, "that the success of the knowledge industry depends on the extent to which it is supported by an information technology infrastructure. This new infrastructure will make possible an even closer interaction with an increasing number of knowledge centres". (Gibbons et al, 1994, p:122) The information technology is thus an essential ingredient for Mode II to operate successfully.

Thus, the "Newt" model proposes that the innovation created in Mode II Knowledge Production will have characteristics of having originated from any possible participant in the collaboration network and with a strong support from modern information and communication technology.

Macdonald's theories consider the concept of innovation from an information perspective. He notes that innovation can be described as a process of mixing some pieces of information to create a new kind of information. The more types of information being mixed, the more likely this mixture may create more radical innovation and in many cases, in order to collect and mix more different types of information there is a need to look outside the organization (Macdonald, 1998). Thus a collaborative research partnership with many participants from different background may create a situation which is conducive to innovation. Macdonald suggests that,

> "when innovation is a new pattern of bits of information, it is legitimate to ask whence come these bits, how they make their way from their source and how they are formed into a new pattern". (Macdonald, 1998, p:57)

Thus in the innovation process these items are important and must be considered. The other important aspect from Macdonald's theory is that to become more innovative there is a need to make sure that each piece of information is ready for use in each component of the process of innovation.

Based on previous theories, the "Newt" model suggests that the main commodity in an effective R & D collaboration is information itself. How to exchange this information is important and may determine the performance of the entire collaboration. In a collaboration involving different participants which operates under Mode II, this requirement poses a particularly great challenge, for these participants may have some problems in understanding each other, given that each participant tries to exchange information in his/her own way.

The "Newt" model defines that each participant will have its own information in its own 'format' and each participant will transact its information in its own 'language'. This own 'format' of each participant is the <u>codification of information</u> and own 'language' is <u>codification of information transaction</u>. *The "Newt" model defines that both codifications used by each participant are dependent on the type of information.* For example: a university will exchange information by using their codification as academics, while people from industry will use the industrialist codification for the exchange of information. This kind of difference may give a different interpretation to the meaning of innovation (and other kind of goals in the collaborative process). Thus, the "Newt" model predicts that there will be a need to establish a medium to help translate the codification used from one participant to another participant.

To accomplish this task the translation system metaphor from Triple Helix is used. The Triple Helix considers a collaborative partnership with partners coming specifically from government, academia and industry. In Triple Helix, each participant will experience a kind of recombination of codes used in their codification which may result in each participant changing its previous codes with another participant's codes. For example: the university may change its codes from academics to 'industry' by beginning to sell their research results (the so-called business research) and industry may start playing roles as 'university' by opening their own education centre or training program (for their own employees).

Thus even though each participant has its own communication codification, there is a chance that each participant may learn and then use new codification from other participants. However having a different codification in the method of communication makes them have a different way of understanding a problem, both their own and those of others (in case of a collaborative partnership) and also their perspective on innovation.

Leydesdorff states the need to have a system which will be able to "translate" the communication codification from each participant to others within this web of collaboration. In Triple Helix, this is called the "translation system". (Leydesdorff, 1997, p:110) As noted earlier in chapter 2, this translation system must be able to operate reflexively, which means that it should be able to detect the communication codification used by each participant on a functional basis (that is only that which is relevant in the context of transacting a particular type of information) and be able to translate it to other participants; and if necessary help participants in adapting the codes used by other participants in order to promote understanding between each other. Thus this translation system must be able to "move" and reflexively execute its task in translating the codes for the benefit of the entire collaboration.

As noted in chapter 2, the Triple Helix requires that this translation system must easily operate and adapt to the dynamics from each participant (internal dynamics) and from outside (external dynamics). The first dynamic is when a participant is adapting itself to change within the web of collaboration, while the second is when the entire collaboration has to adapt to the changing environment from outside. The "Newt" model proposes that the translation system must be available in a CRC collaboration.

The above-described theories will be applied to the case study of the Australian CRC. The way these theories can be applied to CRC is explained in Table 5.1 (given in page 107 to 109). As has been suggested in chapter 4 the Australian situation is already conducive to the creation of innovation from an information perspective.

In Australia, the government has been promoting the usage of information systems and has been supporting the development of the information system (including its diffusion and distribution) to the players of the innovation system. For the "Newt" model, having a well-connected information system means that the operation of CRC can be enhanced and its performance improves. A situation with a well-connected information system makes the application of the "Newt" model more suitable, because both the Triple Helix and Mode II Theories require such a condition. Moreover, Macdonald's information theory and von Hippel's theory of innovation source can accrue many benefits under this situation in Australia, where nearly everyone involved in the process of innovation is becoming connected.

Table 5.1 (I). The four theories and their relevance to the Co-operative Research Centres. Continued on next page, table 5.1 (II). Source: Author's own ideas mixed with various references.

Theory	Important Features	Relevance to CRC
Von Hippel	Source of innovation can come from anywhere in the production process.	CRC collaborative research partnership combines the participants with different backgrounds. At CRC, all the actors involved in the production process are taken into an organization to work together for a specific objective. This will make a more conducive situation for innovation.
Gibbons et.al	Mode II Knowledge Production. The research should be conducted in the context of application. That is, where the researchers from different organization, skills, cognition and social norms are brought together to collaborate for a certain goal which is based on the context of application, rather than 'free' research.	The basic concept of CRC is involving participants from different organizations in research, especially to solve the problems from industry by mobilizing the university and public sector research agencies. This will help to find the solution to the problem of becoming more innovative and will also make Australian industry become more competitive. Working in this way, will enable research to be closer to the context of application because the user of the research is involved right from the start of the research program. Therefore Mode II Knowledge Production is suitable for analysing the CRC operation for the concept of CRC resembles the idea of the Mode II Knowledge Production.
Macdonald	Macdonald's theories stress the importance of mixing several types of information to create innovation. Moreover, Macdonald suggests that high variety and ingredients of information are required in order to create a radical innovation. Radical innovation is thus a mixture of already available information with much more information collected from somewhere else, which is mostly from outside the organization.	The CRC has participants from different types of organization. Each participant has its own expertise, skills, cognitive and knowledge. Thus each participant possesses a different type and probably unique type of information. By putting them together in an organization this will create a place where those information can be mixed, a situation which Macdonald suggests as conducive to the creation of innovation.

Table 5.1 (II). The four theories and their relevance to the Co-operative Research Centres. Continued on next page, table 5.1 (III). Source: Author's own ideas mixed with various references.

Theory	Important Features	Relevance to CRC
Macdonald	Macdonald also suggests the need to have a situation where the type of information required by a participant must be ready made in the format suitable for that particular participant. This situation is important in the innovation process.	Thus, by using the CRC concept, information which has been mixed, may result in something completely new, which may create a radical kind of innovation. This is possible because the participants of CRC are different. Industry may be of different sizes as well as Public Sector Research agencies. Some small-scale vendors may also become participants, ensuring that in CRC there will always be a high level of variety of information. By arranging a system such as CRC where many different participants are combined in an organization, such an objective can be achieved. Furthermore working in this way will ensure that the type of information required by a participant will be ready made in the format which is suitable for a particular participant given that the participant is part of the system which creates that information. Thus from this perspective, a CRC is an excellent setting for a collaborative partnership which can create innovation.
Leydesdorff and Etzkowitz	Triple Helix introduces concept of communication and translation system in having a collaborative research partnership towards innovation.	In CRC, a special consideration must be paid to the different methods of communication between participants. The people from industry, universities and government level are using different methods of communication.

Table 5.1 (III). The four theories and their relevance to the Co-operative Research Centres.
Source: Author's own ideas mixed with various references

Theory	Important Features	Relevance to CRC
Leydesdorff and Etzkowitz	Leydesdorff and Etzkowitz (1998a) define innovation as something that can be considered as the reflexive recombination of specific contexts, for example, between a technological option and a market perspective	This different method of communication may create a different perspective towards innovation. Therefore there is a need to have a translator which will translate code from one participant to other different participants. The Triple Helix will allow us to understand the operation of the CRC for this collaborative partnership operates in the mode where there is a changing role between each participant involved in the collaboration in terms of their used codes (thus a university plays as an industry by selling their research, and industry plays as university by conducting their own research in their research laboratory and providing a training to their employees). Such activities are part of the CRC for CRC also has a training program aimed at industry people. Thus by using the Triple Helix, it will allow us to investigate the operation of CRC better. A translation system (of Triple-Helix) helps us to understand about the way people should collaborate in CRC. By using this concept it can be understood that in CRC, people are working by using different communication codes (or 'languages').

5.2. THE CONSTRUCTION OF THE "NEWT" MODEL

This section explains the construction of the "Newt" model. The "Newt" model has four features which form the base for the development of the *"Newt" style* CRC and which will be explained in section 5.3. These four features are postulated to contribute to the success (or failure) of CRC collaboration. These are listed below.

<u>The first and main feature of the "Newt" Model</u> is viewing the CRC collaboration as an arena of information activity. This may have implication in the relationship among participants on the basis of the type of information being transacted. The information transaction here means all kind of information processing, including: mixing, exchanging, blending and combining all bits of information. Before the process of information transaction can be initiated, the "Newt" model proposes that there is always an *asymmetry* between participants in term of information capacity (repository). The "Newt" model proposes that such asymmetry in information capacity between participants may trigger an imbalance in the relationship between them in the collaboration and under such condition a particular participant may dominate the process of information transaction.

The model proposes that the participant, who has the most important type of information and the largest information repository for the collaboration is in a position to rule the process of transaction of information. On the other hand, all the remaining participants are less dominant in the process of information transaction. The "Newt" model will call the more dominant participant the 'master' and the less dominant participants the 'slaves'[1]. The "Newt" model thus proposes that the need to transact information while there is an asymmetry of information capacity between participants will be based on *a master to slave relationship*. The 'slaves' may become a source of innovation but owing to the nature of the master to slave relationship, the innovation created by the 'slaves' is presumed to be very limited. The "Newt" model proposes that under any circumstance the most benefit gained from an information transaction (including some innovations) will be under the full control of the master.

The second feature of the "Newt" model is viewing the process of information transaction itself. In a collaborative research partnership the participants are coming from different types of organization. This creates a difference in the method of information transaction, which is caused by the difference of codification used by each participant. Thus in dealing with participants from different codifications there is a need to have a 'translation system' which can translate the codification from one participant to others. The "Newt" model proposes that under such circumstances there is a need to have a well-codified medium, which plays the role of translation system. The main task of the translation system is to translate the codification from all participants into the codification of the well-codified collaborative research partnership. This process would be called de-codification. The next task is to develop a new kind of codification in the method of information transaction which can be understood by all participants so that they can easily transact with each other. This second task is called re-codification. However, given that there is a master to slave relationship in

[1] The master and slave metaphors used in this model are not similar as master and slave in a social meaning. The master and slaves are only in an information perspective, more akin to 'master' and 'slave' components in an engineering context.

the CRC collaborative research, there is a need for this translation system to be under the control of the master and become *the translation regime*.

The third feature of the "Newt" model follows the previous two features. Given that there is a master to slave relationship, the translation regime must then be under the rule of a single master.

The fourth feature of the "Newt" model proposes that information technology (especially the Internet) contributes to strengthening this master to slave relationship. As previously described, Mode II is distinguished when different kinds of players are brought together into one single collaborative organization to conduct trans-disciplinary research. This creates a situation where a huge number of types of information are available. At the same time, Mode II also stresses the importance of information technology in easing the process of trans-disciplinary research.

The "Newt" model proposes that this new information technology, especially the Internet, has a significant role in enhancing the master to slave relationship within the collaborative research partnership. The Internet with its application will allow the 'master' more opportunity in getting all the information from the 'slaves' and making it easier to understand their "language". This is because the Internet can help ease the processes of de-codification and re-codification of communications used by the slaves in the collaborative research partnership. The existence of a well codified collaborative research partnership which, can play a role as a translation regime, can form a medium for the realization of such a process. Thus a well-codified collaborative research partnership operating under Mode II, supported by an Internet information system is responsible for enhancing the master to 'slave' relationship. Thus the "Newt" model proposes that the Internet enables the 'master' to better rule the entire collaboration. For the 'slaves' the Internet can help them to better understand the master's codification in methods of communication, which is introduced in the collaboration, so that the 'slaves' can understand the "language" of the 'master', making the process of information transaction much easier. The 'slaves', however, can still create innovation for themselves by mixing the master's type of information with their own information. The construction of the "Newt" Model is given in the following paragraph and in section 5.3 the process of information exchange at CRC under the "Newt" model will be explained in more detail.

THE "NEWT" MODEL

The model postulates that in a collaborative research partnership a participant with the largest information repository will trigger the collaboration and then dominate the entire collaboration. This condition can create a 'master' to 'slave' relationship. Moreover the model considers that a well-codified CRC can acts as a translation regime, which has the main task of translating reflexively the communication codes used among participants in the collaboration. This translation regime is required given the different character of a collaborative research partnership where participants have different communication codes. These codes are basically a mixture of different types of information. A CRC collaborative research partnership can never function as an independent translation regime in the sense of distributing information equally to all participants and making them equal partners. Rather it has to function as a translation regime for the master's benefit only. The model dictates that CRC collaborative research partnership is based on a 'master' to 'slave' relationship. The model considers that there is a need to have an Internet information system in order to achieve a conducive 'master' and 'slave' relationship in a CRC collaborative research partnership.

5.3. THE "NEWT"-STYLE CO-OPERATIVE RESEARCH CENTRE

The participants of CRC come from three different types of organizations (academia, industry and the Public Sector Research agencies, PSR), therefore they have different motives, skills, expectations and expertises. The basic idea of CRC is to bring them together to find solutions for the problems of the industry participant. In this process it is expected that not only the best solution can be found but also innovation can be created.

For the "Newt" model, whether it is the solution for a problem or a created innovation, there is a new type of information being created from a mixture of several types of information. For the university participant this new type of information, can be used to help create a new focus for a new kind of study, which could be offered in the university curriculum i.e something, that may trigger the exploration of a new dimension in the basic research. Meanwhile the new type of information is obviously also important for PSR participants. The solution of industry problems by the use of this CRC model can be conducive to creating innovation because when different types organizations are being combined there will be a mixture of information from a different perspective and theoretically this will create a new kind of information, which is actually the innovation itself.

Apart from this, the solution of the problem encountered by industry using this model will create a spin-off of information, which may trigger a new kind of innovation.

For the "Newt" model, the main commodity, which is transacted in the CRC is a particular type of information. The transaction of this information is conducted in a well-codified mechanism of information transaction among participants. Each participant has its own information, which is different both in terms of its quality and quantity to that of other participants. Moreover each participant has a different cognitive understanding with respect to its own problem and other participant's problems. In the participants' endeavour to pursue a solution for the problem through this collaborative research partnership (and also to create innovation) some participants may have to change their codification used in the method of information transaction reflexively.

This concept enables a reflexive translation of different codification from different participants, which obviously are "speaking" and communicating with different "languages" and have a different perspective about all aspects of the collaboration. For the "Newt" model the CRC functions as the translation regime, which has to translate different codification in the method of information transaction from different participants in the collaboration. The CRC is supposed to "detect" the codification of method of information transaction used by participants and translates them to other participants and to do this in a reflexive way. In this way CRC can help to make sure that each bit of information is ready for use by each participant, a condition, which is suitable for finding a direct solution to problems and is also conducive for innovation.

Furthermore for the "Newt" model, the director and board of directors of CRC are functioning as main elements in the translation regime. They have the task of translating the codification in the method of information transaction used by their respective organization to other participants through the information transaction, where the main commodity exchanged is actually information (which is mostly in a codified format). The "Newt" model suggests that to execute such a difficult task, the director must be someone with the qualifications (or equivalent) of an industrialist, academic and public sector employee in order to understand all the codification in the method of information transaction used by each participant in the CRC. As previously noted, CRC is a formal collaboration and thus the process of information transaction is well codified. It is the task of the translation regime to understand this codification and de-codify it for the other participant so that every participant can understand the meaning of the transacted information.

During the process of de-codification and re-codification of this information this translation regime may experience evolution. This is caused by the fact that during the process of exchanging information (including the codification and de-codification process), some new codifications can be created and developed (the codification is basically in the method of information transaction and is dependent on the particular type of information). Thus in each process of creation of a new type of information a new mode in the translation regime is required and this process will happen continuously, during the course of the program. Over the course of the program, the dynamics of information exchange in the collaborative research partnership may evolve. It must be noted that since collaboration at CRC is conducted in a formal way, the process of de-codification of information is always followed by a new created codification. This new codification is supposed to be well understood by each participant of the web of collaboration.

For the "Newt" model, participants can start transacting information only once the process of creating new codification has finished. Once all participants use the same codification of method of information transaction, all types of information from different participants with their different codification, can now be mixed with others. This may create a new kind of information, which is actually an innovation. The "Newt" model proposes that normally, in this kind of situation all newly created information requires that each participant involved in the collaboration program adapt the method of information transaction, which has been used before. This requires the development of a new layer of the translation regime. The translation regime thus plays a role as an adaptation process.

For the "Newt" model a capability for the translation regime to adapt may contribute to the success of a CRC. Moreover, it may provide a conducive situation for innovation, given that the source of innovation can come from anywhere and at the same time the availability of the translation regime will enable such condition to be created so that all the required information can be made available and understood at anytime by all participants. *Thus the "Newt"-style CRC suggests that working in a CRC collaboration will always enable the creation of an environment to make each participant become more innovative provided that the CRC can play its role as a proper translation regime. Conversely, failure of an adaptive translation regime can lead to the failure of the CRC to meet its objectives.*

5.4. THE 'INFORMATION MIXING POT'

In relation to the Newt model and information transaction it is necessary to introduce the concept of 'Information Mixing Pot'. This is a virtual place where the process of information transaction takes place. Figure 5.1 pictures the 'inside' construction of the 'Information Mixing Pot'. The process of mixing information in this mixing pot consists of two steps. The first step is the process of comparison between the type of information coming in from the 'slaves' with the type of information submitted by the 'master'. The comparison process removes all types of information undesired by the master. The second step is codifying the compared type of information. This produced type of information is submitted again in the Information Mixing Pot after the first 'cycle' (figure 5.1) and this will become the new input for the master to change (and thus to adapt) the selection procedures. Using this way, the Information Mixing Pot is able to reflexively adapt to all possible changes from the environment. These changes are the main dynamics within the Information Mixing Pot.

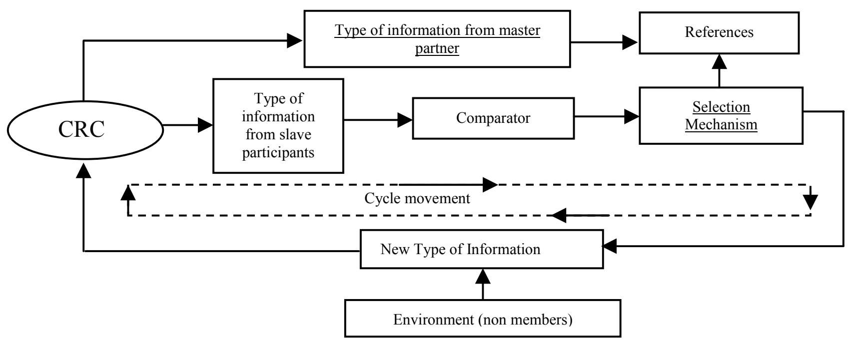

Figure 5.1. The mechanism inside the 'Information Mixing Pot'. Source: Author.

For each cycle of the inflow and outflow of information in the Information Mixing Pot, the process may evolve and result in new dynamics in the process of information flow (figure 5.1). These new dynamics may create a new niche of second order dynamics. The second order of dynamics are based on the comparison between the information flowing-in and the information flowing-out with the previously already existing information available in the Information Mixing Pot (including that from the master) (figure 5.1). This second order of dynamics will interact with other dynamics resulting in a complex system within the Information Mixing Pot in the later stages (see figure 5.1, the cycle in the dashed line will move in continually). This complex system will produce more references for the dynamics of the entire system in the Information Mixing Pot (figure 5.1). In practice, these new dynamics are the creation of spin off in the CRC collaboration programs. However the nature of these dynamics may either be: (1) stagnant, (2) continuing to a stable process or (3) continuing to an unstable process.

In (3) this may result in a chaotic situation within the dynamics (such as less efficient information flow or that the 'Information Mixing Pot' does not work properly and/or does not result in a new type of information and/or new references). For the Newt model, this may mean the cessation of the CRC collaboration program.

Thus, controlling the dynamics is based on the establishment of an institutionalized translation and it is the responsibility of the master. This master must operate very well to be able to maintain the dynamics especially in: (1) controlling the type of information coming in and coming out; what type of information is very important in the dynamics and will be the determinant for the success or failure of the dynamics, (2) the intensity of information inflow and outflow; this intensity must be kept as such so that new references will be available in a particular given time so it will be able to control the new dynamics. It must be noted here that for one cycle of dynamics, a new kind of environment is generated which requires a new kind of information to be used as a reference and to be able to control the new dynamics. When the dynamics changes, a new kind of information sub-set is needed to control it, and (3) the direction of it; the direction of the dynamics must also be carefully controlled. The direction of the dynamics may evolve to a new direction, which would not be conducive for the collaboration, which is the next cycle of the dynamics and therefore maintained control must be exercised in the dynamics. Such maintained control in the dynamics must be based on a well-codified operation and must be based on a formal agreement between the participants in the dynamics.

In practice, the CRCs did this, by putting representatives as agents in the institutionalized translation. Within this institutionalized translation another agent ('translation agent') which, translates all the information from each participant must have been elected and this agent performs as a new translator for this institutionalized translation. The dynamics of the evolution is dependent on the tacit and tangible knowledge of the translation agent.

In fact, the dynamics in the 'Information Mixing Pot' ('the cycle movement' in figure 5.1) is dependent solely on the interaction between master and slaves. Normally the master dominates the dynamics of the entire system and drives the direction of the dynamics of the information transaction and therefore the process of evolution. The selection mechanism occurs in the 'Information Mixing Pot' but basically this is something, which is built up by a complex interaction between the participants of the CRCs. This complex interaction between participants however is under the control of the master.

The existence of an 'Information Mixing Pot' creates a situation where the slaves have to change their codification (in the process of the information transaction) in order to enable better interaction with others in the information transaction, which is controlled by the master.

The realization of an institutionalized 'Information Mixing Pot' is the establishment of the CRC Board of Directors. This board will act as a translation regime within the web of collaboration. The main objective, which has to be discussed within such a board is the decision to select one among the available priorities in terms of functionality of the codification for the entire collaboration. As noted previously the CRC itself, for the Newt model, is the translation regime. However, in practice, the Board of Directors is actually the *real translation regime* in the CRC. Therefore the establishment of a broad-ranging personal network of Directors of the CRC may extend to the coverage of the Information Mixing Pot beyond the CRC organization network. However, the master to slave relationship prevails.

5.5. A RESEARCH METHODOLOGY TO TEST THE "NEWT" MODEL

A field survey was conducted to test all postulates and propositions listed above. The survey was conducted from 9 June 1999 till 25 October 2000. The results and analysis for this thesis are based on CRC conditions during the survey period that is mid 1999 to late 2000. The survey is aimed to assess the dynamics of information exchange at the top management of CRC because as a well-codified collaboration, management determines the process of information transaction. Thus the survey will consist of an in-depth interview with several key figures in some CRCs, while the test is aimed to compare the "Newt"-style CRC and the actual CRC based on the following hypotheses:

Hypothesis I: The "Newt" model sees the collaboration within CRC from an information perspective and views the relationship among participants on the basis of information being transacted. In such a transaction there exists an interesting relationship between master and slaves. The master is the participant that possesses the largest repository of the type of information, which has the main role within the CRC collaboration. Thus, this information must be the type of information, which triggers the collaboration. Therefore this participant is in a position to control the collaborative research partnership, because this participant has the capacity to control the transaction of information within the web of collaboration. The model thus states the importance of particular types of information, which will determine the operation of the entire CRC collaboration. The model hypothesizes that the 'master' is the only partner that controls the type of information that triggers the collaboration.

Hypothesis II: Furthermore, the model hypothesizes that the 'master' controls completely the transaction of all information, including the process of mixing this information with other types of information from other participants. Thus the innovation which is created is a direct derivative of the type of information provided by the master. The type of information the master provides is improved and expanded both in terms of its "value" and "quality" by mixing it up with other types of information, again under the complete control of the master.

<u>Hypothesis III:</u> The model hypothesizes that given this master has such authority, it is this master which gets most of the benefit of the innovation process and this master is likely to become more innovative than other participants (the slaves). The model also hypothesizes that the master's information capacity will increase when working in this CRC.

<u>Hypothesis IV:</u> The model hypothesizes that the master gets more powerful through the course of the collaboration. This kind of knowledge production enables the master to learn a new kind of knowledge and to participate in the production of a new kind of knowledge which increases their knowledge capacity (more and better knowledge).

<u>Hypothesis V:</u> Moreover, the model hypothesizes that the existence of the translation regime actually helps to create a more conducive situation for the master to exercise its position as the ruler of the entire collaboration. The CRC allows the master to understand what the codifications of the method of communication for the slaves of the collaboration are, so that the CRC allows the master to "speak" with the slaves within the web of collaboration. This puts the master in a position of control in the process of translating codifications (and thus the information). Thus, finally, the slaves can be fully controlled by the master. By the same token, the CRC as a translation regime has to serve for the benefit of the master only and not for the sake of the entire participants of the collaboration.

<u>Hypothesis VI:</u> The model hypothesizes that the Internet information system contributes to the creation of a master to slave relationship in collaborative research. The Internet helps the process of de-codification and re-codification of the method of information transaction used by all participants. However, the Internet also supports the transaction of the types of information so that it can create innovation.

Hypothesis VII: The information repository of the master can grow in the course of the collaboration and this allows the master, to become more powerful than the other participants (the slaves). By the end of the CRC's life, the master will have become the strongest participants (in terms of the information repository). As such the master has a powerful role in determining the course of collaboration. The master is likely to keep on collaborating so that the information mixing process which is beneficial for the master can remain under its control and so that it can accrue the most benefit from the collaborative research partnership. The model hypothesizes, that it is this master which determines which (slave) participant should get what particular type of information. In this way, in the long run, the master may determine what kind of innovation can be generated through the CRC.

SUMMARY For the "Newt" model, the CRC is thus a master and slave relationship. However, the "Newt" model stresses that the CRC itself is *not* the master but that the CRC acts as a medium for the master to become more powerful and be able to exercise its rule among other participants. The only participant likely to become most innovative is thus the master. The types of information which are important for the collaboration come from the master. Innovation is created by combining this information with other information from the slaves. Any innovation which is created in the CRC is directly derived from the type of information contributed by the master. However the slaves may still benefit from this collaboration through mixing information to create a new type of information is beneficial for them.

To test the four features of the "Newt" model; this model is applied to the CRC case studies. For this purpose, there are three CRCs under consideration these are: CRC for Welded Structures, CRC for Quality Wheat and CRC for Advanced Computational Systems. The reasons for selecting these CRCs are as follows:

- <u>Appropriate reason</u>. The "Newt" model is assumed to work in any CRC. Thus the selection of CRC can be randomly however the CRCs selected must resembles a high degree of difference in their themes, this is in order to analyze whether there is a specific type of information that triggers the CRC collaboration as well as to analyze the existence of the 'master' that provides such type of information. Given limited time and costs for conducting the survey, the other consideration is also the location of the CRCs. Moreover it would be very interesting to assess the "Newt" model in a CRC with a complex web of partners, which may present a real master to slave relationship (that is one master with many slaves) and thus allowing for an analysis of how the master controls the entire collaboration. The selected CRCs are: CRC WS which is dealing with welding technology and based on the University of Wollongong; CRC QW which is dealing with agricultural activity and based in Sydney; and ACSys CRC which is dealing with computer application for computational and graphics purposes and based in Canberra.
- <u>Comparison of performance</u>. These three CRCs have each had a different history of performance. For example: the CRC for WS evolved to a new CRC and received a compliment as one of the most successful CRCs. The ACSys CRC closed down. While the CRC QW is still within its first cycle of funding[2]. The different conditions in these

[2] CRC QW was in 1st cycle of funding when this report was written in 2001.

three CRCs is interesting for testing whether the model is applicable to a range of CRCs and especially in order to investigate whether the model can explain the success or failure of CRC operation.

- <u>Topic of research.</u> These three CRCs are an attractive topic of research. Economically all three CRCs are important for the Australian economy. From the perspective of the "Newt" model, these three CRCs are also attractive, for they have a wide range of partners. A broad partnership allows an interesting web of information transaction and this is a good example of being able to see whether the proposed translation regime can actually work. The CRC WS covers membership from a large business organization (such as BHP) to individual welders scattered across the country. Welding itself is a very important activity in the manufacturing process. The same applies to CRC QW. The participants in CRC QW are also diverse and come from different areas such as from a large food processing company (such as Arnotts biscuits) to individual growers. The last case study, ACSys CRC has similar features. This CRC is dealing with information technology, a sector which is growing fastest in the world. Moreover in terms of membership, ACSys CRC is a unique case study. ACSys CRC combines a contrast partnership among large multinational companies such as Sun, Fujitsu and SGI with many smaller, local Australian companies including several Small Medium Enterprises (SMEs). Furthermore, ACSys CRC is dealing with information technology, the technology, which allows the Mode-II Knowledge Production and Triple Helix to emerge and operate. The model developed in this chapter is of interest in its applications to such working environments.

The field-work involved selected interviews with several key figures in the above CRCs. As has been previously discussed people from the board of directors are postulated as the elements of the translation regime of the "Newt" model, which is one of the main ingredients of this model. Thus the main target of this qualitative testing was members of CRC Board of Directors and CEOs of CRC's. However, in order to get a clearer understanding in some cases, the interviews were extended to include some other personnel in each CRC, such as project leaders.

5.6. CONCLUSIONS

This chapter has described the new model to analyze the importance of information system by understanding the process of information transaction in the CRC operation. The new model is called "Newt" model and this model views the CRC's collaboration from an information perspective. Based on this perspective the collaboration at CRC is analyzed on the basis of the relationship among participants in transacting the information within the collaboration. This model introduces the existence of two kinds of participants, the dominant ('master') and the less dominant ('slaves').

The master holds the main type of information, which triggers and drives the entire collaboration. The slaves deliver other types of information, which have a less significant role in the CRC collaboration. The master is the participant that not only has the largest information repository but also has the most varied type of information. The "Newt" Model proposes that the collaboration within CRC can be viewed as a process of refinement and improvement of this master's main type of information within a dynamics which is contained in the 'Information Mixing Pot'. Moreover the "Newt" model proposes that the master is the participant which has the largest information repository. The collaboration is used by the master in order to improve this main type of information and refine it for its own benefit. The slaves are actually helping the master in this process, that is, by adding additional and new information to the master. The innovation created in the CRC is basically derived from the main type of information from the master. The innovation for the slaves consist of pickings from the master's innovation, given that mixing types of information with other types will still create innovation. The master's role in controlling the entire collaboration is simplified and supported by the existence of CRC itself.

The "Newt" model further postulates that CRC is a translation regime, which helps the process of de-codification and re-codification of information used by different participants in the collaboration. By functioning as this translation regime, CRC can help the master to understand the codification from the other participants (the slaves), which in turn will strengthen the master's position in mastering the entire process of the information transaction. Thus the role of translation regime for CRC is for the benefit of the master. Moreover the Newt model suggests that the effectiveness of CRC operation is dependent on how good the CRC can function as translation regime for the master.

Finally the model postulated that the Internet information system has a crucial role in the CRC collaboration. <u>Firstly</u>, the model argues that from an information perspective the Internet plays a significant role in enhancing the master to slave relationship within this CRC. That is, the Internet helps to simplify the 'introduction' of the most important type of information in the entire collaboration and in the course of the program the Internet simplifies the master in controlling the flow of information within a web of collaboration. The Internet also supports the operation of the translation regime, which makes the master "understand" the slaves easier and faster. This happens by simplifying the process of de-codification and re-codification of information. Secondly, the Internet provides a way for the master to sustain its position as the master, which rules the flow of information and mixing of information in the collaboration.

The "Newt" model hypotheses that the operation of CRC is dependent on this master to slave relationship. Therefore, the model stresses that the CRC has to operate under control of the master and this master to slave relationship must remain intact for this CRC to succeed. As long as such a condition can be maintained the CRC will continue to operate, otherwise the model hypothesises that the CRC may cease to operate.

In general the model is optimised to propose a new alternative to provide better understanding of the CRC collaboration especially in its process of information transaction which may contribute to the success of CRC operation. Some policy implications may follow and this will be explained in the subsequent chapters.

CHAPTER 6. CASE STUDY 1: THE CRC FOR WELDED STRUCTURES (CRC WS)

"The Co-operative Research Centre for Material Welding and Joining (CRC-MWJ)[1], was formally established in July 1992. The first core participants of this CRC were two universities (The University of Wollongong and the University of Adelaide); two public sector research agencies (The CSIRO Division for Manufacturing and Technology and the Australian Nuclear Science and Technology Organization); an industry, the Broken Hill Pty.Ltd (BHP) Steel and an industry association; the Welding Technology Institute Australia (WTIA). This is a typical combination for a CRC, which puts emphasis on the collaborative formation between University, Industry and Government sectors". (CRC MWJ Annual Report, 1993/94:p 4) The structure of the CRC WS collaboration is given in more detail in figure 6.1 (see next page).

The Australian Welding Technology Institute (WTIA) has a long history of co-operation and a well-proven infrastructure for collaborative research. The role of the WTIA in assisting the CRC's link with industry is important. The 400 companies and 1500 individual members across Australia related to welding and joining provide both industrial input into the programs and activities of the CRC and are particularly important as a vehicle for effective technology transfer of the output of the CRC[2]. The WTIA membership of CRC MWJ is important, for the current world trend requires a new focus in dealing with R & D. The WTIA (and later the APIA) creates a niche where the users of the technology and innovation and their creator are in the same working entity.

[1] CRC for Material Welding and Joining is the previous name of CRC for Welded Structures.

The APIA was established in 1968 and provides a forum for the discussion and resolution of issues facing the pipeline industry[3]. The main mission of APIA is to lead the development of a dynamic Australian pipeline industry. Members include contractors, owners, engineers, suppliers, financial and legal companies and other organizations providing service to, or having an interest in, the pipeline industry. APIA has grown strongly over recent years, with corporate membership approaching 250[4]. The involvement of APIA will secure the continuation of the existing level of research undertaken for the pipeline industry and provides a platform for growth because of that industry's demonstrated need for research activities in areas beyond welding and joining. (CRC WS 1999-2007:p 13)

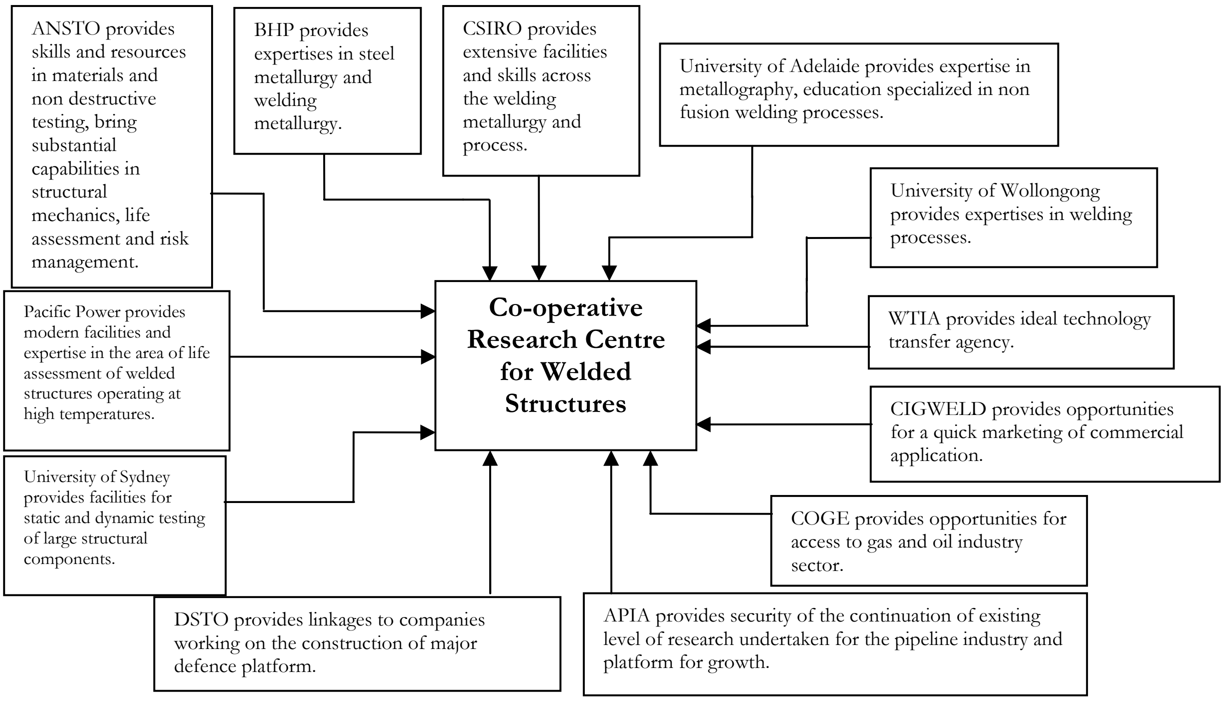

Figure 6.1. Participants in the CRC WS.
Source: Author, compiled from several CRC WS Annual Reports.

While the key objectives of this CRC is given in the following caption,

[2] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[3] From: http://www.apia.com.au/about retrieved at December 4, 2000
[4] Ibid.

> "The key objectives of CRC MWJ are (a) bringing together major Australian groups involved in the fields associated with welding and joining; (b) conducting research to enhance productivity and product performance; (c) conducting research to develop new areas of the technology; (d) providing industry with postgraduate qualified engineers through the co-operation of the universities and the research and industry partners in research projects and coursework program; (e) disseminating information to industry and partners in research projects and course work program; (f) disseminating information to industry and others in the fields; (g) the transfer of technology by direct interaction with industry" (CRC MWJ Annual Report, 1993/94:p back-cover)

This chapter discusses the application of the Newt model in order to explain the process of information transaction in both the establishment and operation of CRC WS. The objective is to investigate whether and how this model works in this particular CRC. The discussion in this chapter is based on qualitative analysis using data and findings collected from field interviews of some important figures[5] from the CRC WS.

The organization of this chapter is as follows: section 6.1 discusses the establishment of this CRC from an information perspective especially the investigation of the crucial type of information which triggers the entire collaboration. Section 6.2 discusses its operation from an information perspective, most importantly the investigation of the relationships among participants and the role of the information system in the operation of CRC. Section 6.3 discusses the application of the Newt model to explain the process of information transaction in this CRC. Section 6.4 discusses to what extent the Newt model works in this particular CRC. Finally section chapter 6.5 presents some conclusions.

[5] Listing of the interviewees and their position are given in Appendix 1.

6.1. THE ESTABLISHMENT OF CRC WS FROM AN INFORMATION PERSPECTIVE.

This section describes the analysis of the establishment of CRC MWJ from an information perspective. The objective of this section is to identify what is the critical type of information which has triggered the collaboration and to identify how this information flows within this collaborative research partnership.

The origin of this CRC cannot be separated from the role and involvement of BHP and WTIA[6]. WTIA is a big consortium and has in total 315 industry members from various sizes in welding technology and business, while BHP is the largest industry in the region of NSW and one of the largest in Australia. The first members of CRC MWJ were WTIA, ANSTO, BHP, CSIRO and two universities: UoW and UoA. The establishment of CRC MWJ (later called CRC WS) from an information perspective will be explained as follows. In order to identify the critical type of information and information flow mechanism within this collaborative research partnership, the following approach will be used: (1) From where the information is coming; (2) what type of information drives and gives birth to this CRC, and (3) how does it come there and (4) how is it used.

The main core participant for CRC MWJ was BHP in Port Kembla, NSW. It was, actually, BHP, which in 1990, initiated the establishment of CRC MWJ[7]. BHP's intention to initiate the collaboration is also reasonable from an information perspective, because there is a need to combine both types of information external and internal, also there is a need to create a

[6] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, March 8, 2000.
[7] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

conducive situation which will reduce the unwillingness of the firm to mix this information[8]. Thus forming an organization such as the CRC MWJ is a move that achieves both objectives. In fact, the more complicated and extensive the problems are, the more it is required to increase the scale of collaboration (that is: to expand it in order to get more members so that more external information can be achieved).

"The welding business in Australia is getting more important and strategic given that currently the life span and safety of welded products/structures produced by Australian companies are the key to future sustainable economics of structures such as gas, pipelines, power stations, ships, offshore oil and gas platforms, other transport equipments and a mass of equipment for petrochemical and other industries. Moreover welding has become, a high technology activity using leading edge physics, material science, electronics, robotics and computer science. It includes the use of high power lasers, plasmas, electron beams and controlled arc phenomena". (CRC WS 1999-2007, p 2) In general, the establishment of this CRC was in order to meet the demand from industry. The following quote from a member of CRC WS Board of Directors illustrates this:

> The existence of this centre is to meet the needs of industry. All those industries are ships in the night. How can we meet their needs? So by identifying the network, by using this CRC, we can find any solution to meet any need of the industry[9].

In particular, it was the Broken Hill Pty. Ltd (BHP) Steel in Port Kembla, which initiated the establishment of CRC MWJ, as the CEO and founder of this CRC points out:

> Yes, actually, in 1990 I worked for BHP in Port Kembla. That was steelwork and it was actually my idea to set up this CRC for Material Welding and Joining. And that was successful[10].

[8] Ibid.
[9] Interview with Mr. Christopher Smallbone, Executive Director of WTIA, March 8, 2000.
[10] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

BHP sponsored the establishment of this CRC in order to pursue *a new method to calculate welding time by trying to develop a network of a wide range of skills and expertises*. The following quotes from CEO and founder of this CRC illustrate this point:

> The industry [BHP] comes up with the views. Welding time is our [BHP] problem. So how can you help us [BHP] ? and then our mind will start to work. May be, we can do this, and this, etc. But the initial idea was driven by industry [BHP]. Help us [BHP] with welding time in the pipeline. And I go the site and say, " maybe I can do this, and this. And I present to the industry, what I can do. And then, they put some money on the table, and I go to work[11].

> BHP Steel in Port Kembla needs support to deal with more complicated problems dealing with welding time in pipelines and welding technique for pipelines. For BHP Steel, the main objective of the establishment of this CRC, was to link the best experts in Australia to help the steel science business and to solve the problems related to it especially from a technological perspective[12].

The following quote from a BHP Steel Executive further reinforces the point:

> Well, we have not really just used the University of Wollongong as research partner. We were very, self sufficient in terms of research capabilities many years ago. But, with review of cost restructure, we have moved away from having that research facility in-house. We are now looking at utilizing expertise in other areas. And, this CRC, represents that centre of excellence which doubled our expertise. But, really, I can say, we joined this CRC because it was called, Material Welding and Joining. We joined, that was eight years ago, when we still had a very large level of in-house research capability. So we were looking at exploring synergies, to get effect to our results that we can get from being involved in a broader range of research organization[13].

This particular type of information (the welding time) was also the information, which has attracted the other members to join this web of collaboration[14]. In relation to this technical type of information, another type of information, which is relevant to be considered as important for the establishment of this CRC collaboration is that which could help industry understand technical problems and possible market information. The following quote illustrates this perspective:

[11] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[12] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[13] Interview with Dr. Frank Barbaro, BHP Steel Division, October 4, 2000.

> Sometimes the industry does not know what the real problem is. I have to ask them to do this technical analysis, or sometimes I have to give them a broad idea. For example: this year, I am going to put a small amount of money, A$ 10,000 into Solar Welding. What can we do with the solar panel in the outback and welding from it? Is it possible and profitable or not? Now, this is, sort of, very blue sky. Now, if industry tells to us and says: "We want this research. We expect that this research has application in pipelines". So, it is industry driven research, but we do some blue sky work as well[15].

So it can be seen that the origin of this CRC is mainly caused by a more complicated problem in dealing with technical issues especially from industry. Australian pipeline is very unique in the world, given the small Australian population with sparse distribution, there is a need to have a high pressure, thin walled and very small diameter pipelines[16]. Because of its unique feature, there is no way to find any similarities in the world[17]. Therefore all problems encountered with this kind of pipeline must be solved by using local knowledge. So, in order to build a low cost, and more efficient pipeline, there is pressure to create a network dealing with the same topic. BHP in Port Kembla needs to save hundreds of million dollars in these pipelines. The following quote from the CEO of this CRC illustrates the uniqueness of Australian pipeline:

> They are not calculating the benefit except for the industry. I think, what we are talking about is not just bringing the world best pipelines. It is a unique situation in Australia, where we had to work together to innovate ourselves[18].

Moreover, the Australian Pipeline Industries are also faced by this similar problem (dealing with welding time), as the CEO of this CRC points out:

> The Australian Pipeline Industries have been looking at a method to reduce the cost element for the welding and welding time. This may not have been the biggest cost of the total cost element, but it was the major rate at any extent in installing pipeline. At that time, in the past, installation was running about 4 kilometres per day.

[14] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[15] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[16] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[17] Ibid.
[18] Interview with Dr. Frank Barbaro, BHP Steel Division, October 4, 2000.

> Australian Pipeline Industries have been seeking for a method for reducing the installation time in an efficient way[19].

The following quote from The Executive Director of the Australian Pipeline Industry Association (APIA) reinforces the previous statement,

> Now in a research, that was CRC, which identified the quantitative way we can release the clamp much earlier than had previously been the case. And in fact that allowed many of our pipelines, which is that one from Ballera[20]. to this place, the pipe line is to be built at an average rate of 8 kilometres per day. And a maximum rate of up to 20 kilometres per day, which has been a long time record, and saved a lot of money. This is because you did not have to mobilize workforces as much, so it was very efficient. And that same research in the other components of research on this CRC WS program, lead to an estimated say A$ 10 million on the Eastern Gas Pipeline, which is stretching completely from Melbourne to Sydney. So, it has been a significant cost saving there.[21]

The APIA joined this CRC because it was interested in gathering the information related to the application of welding technology and techniques specifically in pipeline design and constructions[22]. *Thus the welding-time is a very important type of information for triggering the establishment of this CRC.*

The other participant of this CRC, the Australian Nuclear Science and Technology Organization (ANSTO) is also faced by the need to conduct research dealing with welding and joining. Actually ANSTO is dealing with nuclear research activities, but nearly all the building and construction sites of ANSTO must be properly and safely constructed in order to prevent problems such as radiation leaks and the like[23]. There is thus a need to have a deep knowledge about welding technologies and techniques since all those buildings are joined by welding.

[19] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[20] See also the success story of CRC WS: "Improved Welding means Cheaper Gas" in Appendix 5.
[21] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[22] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.

The ANSTO Material Divisions then decided to join in promoting the establishment of a CRC dealing with this need in order to make sure that a deep knowledge in this field could be gained. ANSTO itself is particularly active in applying their capability in nuclear technology in their welding activities and seeking possible relationships with other research organizations in order to find the best practices and solutions to deal with the challenges in building safe nuclear facilities. The Director of ANSTO Material Division illustrates this point:

> ANSTO felt that we could gain much, by working with others in the welding area and could provide synergies, by combining our expertise and facilities with those of our partners for our benefit[24].

The other participant of this CRC, the WTIA is interested to join the promotion of this CRC collaboration because of its interest in the type of information related to welding technology and all aspects of welding[25]. For WTIA, participating and supporting this CRC will make them become more attractive to other industries to join them and to use them (their service) in order to find the solutions to the industry's technological problems (and to help some industries to become more innovative)[26]. Besides the technical type of information as the main driver of collaboration, the other driver of collaboration is to get access to funding for conducting R & D (a low cost entry to R &D)[27].

Another important consideration in the setting up of this collaboration is to provide access to facilities, especially in a country such as Australia, where it is difficult to create critical

[23] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000.
[24] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000.
[25] Interview with Mr. Christopher Smallbone, Executive Director of WTIA, March 8, 2000.
[26] Ibid.
[27] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

mass to advance ahead of the competition without teaming (collaboration)[28]. Furthermore, there is a need to deal with common issues, which are normally regulatory, as pointed out by The Executive Director of WTIA who is also a member of CRC WS Board of Directors:

> We have to unite. Because, remember each part of this pipeline, is in different states. So we have different state government with which to deal. We have very different issues with the state government and we try to bring our concern of the whole industry view and use that to increase our leverage in encouraging government to all our thinking. And that is very important. And we have been more successful in the last three to four years in particular[29].

Thus the type of information, which drives the setting up of the collaboration, is mainly, technical and more specifically type of information which deals with the method of how to reduce welding time particularly in pipeline construction. Furthermore the flow of this information within this CRC must be based on three most important aspects[30]: (a) definition of the technical problems; (b) definition of the outcomes and all the benefits to that level and; (c) knowing where to stop in order to avoid friction among members with regard to their business activities for gaining profits (pre-competitive issues).

Currently CRC MWJ, which has changed its name to CRC WS has won the second round of CRC selection from the government and has grown to have in total 13 core participants plus 40 co-industry partners[31]. The reason for changing the name is again caused by the type of information. This new CRC which actually grows out of an already strong foundation in the CRC MWJ which was identified as "one of the most effective CRC that directly support Australian Industry". (CRC WS 1999-2007, p 1) "The business plan for the new CRC has been designed to collapse the value chain of activities involved in the total product life-cycle

[28] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000.
[29] Interview with Mr. Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[30] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[31] Ibid.

engineering of welded structures, whilst leveraging excellent client access generated through the existing centre." (CRC WS 1999-2007, p 1)

The main significant extension to the CRC WS is "broadening the vision from welding to the total life cycle of welded structures, which includes design, construction, maintenance, life extension and eventual decommissioning". (CRC WS 1999-2007, p 1) Thus there is a need to get more types of information in order to deal with the more complicated problems faced by the CRC MWJ, so that they have to evolve into a new CRC. The type of information, which is purely concerned with the field of welding and joining is no longer sufficient to handle the entire problems of Australian industry and needs to be expanded, as the CEO of this CRC points out:

> There was really a learned experience from the previous CRC MWJ and industry. Historically, over the last seven years we had been involved purely in welding and joining and that was really restricted to welding and joining metal and steel together. However the implementation of welding and joining really depends on a much bigger process chain. What I mean is, you have to design something, then you have to fabricate it, including welding and joining but not explicitly welding and joining. I mean it might be forming, then welding and joining, then operation, then maintenance and ultimately at the end of the life, decommissioning. What I mean is, for example, our offshore platforms increasingly are having to be designed and fabricated with the guarantee in the end-of-life situation in mind. What do you do ? Do you put an explosive in it ? Hopefully not. You must of dispose them in some environmentally good way. So we were locked, in the previous CRC, to one part of this process chain. Now, we change the name, but that weld is still here [32].

The above quote indicates that the type of information sought by industry participants is getting more challenging, more complex, and more complicated, and it needs the establishment of a new kind of collaborative-research-entity. The need to mix the information from various entities has made the main idea is no longer limited to welding and joining but now has to be extended to the total product life cycle of welded structures. The

[32] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

next section discusses how this type of information is transacted between participants in this CRC.

6.2. THE OPERATION OF CRC WS FROM AN INFORMATION PERSPECTIVE

This section discusses the process of transaction of the types of information addressed in the previous section. Sub-section 6.2.1 discusses this process of information transaction in this CRC. This is followed by subsection 6.2.2, which discusses of the role of the Internet in this process of information transaction.

6.2.1. THE PROCESS OF INFORMATION TRANSACTION

The process of information transaction in CRC WS is started by organizations: BHP, WTIA and APIA which submits information to the other participants of this CRC (ANSTO, USA, UoW, CSIRO and others)[33]. For industry consortiums such as WTIA and APIA the information they submit also comes from their members. The information from WTIA comes from 315 members of WTIA plus some more from the Ozweld consortium, while from APIA there are 220 members. It must be noted here that the nature of this information is as pre-competitive information[34]. This submitted information mostly deals with industry problems faced by BHP in order to solve purely technical problems related to welding and joining in pipelines and engineering construction application and explores and enlarges the capability of research in welding and its applications[35].

The information is submitted by each participant in their codification. Thus codification of information used in this CRC is dependent on each participant which is mainly dealing with

[33] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

information related to the technical problems encountered by industry, as indicated by the CEO of this CRC:

> We exchange mainly technical information. The difficulty of the CRC is really to capture some of the benefit in the pipeline industry. We save at the moment A$ 10 million. My view about this is, can I have five per cent of that for research. And if industry says "no" then I can't use it for research. And I say back, "You as cash consumers benefit through the cheap pipelines". There is a difficulty in this, in terms of the fact that, CRC is receiving or just assigning it from the industry. We of course hope that those industries still contribute cash to CRC and stay as partners, so that, there are some benefits flowing back to us in that regard. The other very careful thing that you should know, is that we have two partners of association. One is the Welding Technology Institute Australia, which has 250 members and also the Australian Pipeline Industry Association, which has 220 members. What these organizations bring to us is, with two representatives, one from each, that they represent 470 other companies, they can hopefully represent the needs and wants of that industry sector. So I would say we have a lot of partners. And of course that is not only useful in terms of helping us to understand better the industry's needs, they are also extremely helpful in extending our technology out there in industry[36].

For example, the PSR agencies operate as given by the Director of ANSTO Material Division:

> We did not change our organizational structure for the sake of the CRC. I am sure no other organization has done so. I think it is more important to recognize that there have to be some organizational culture matches before organizations will collaborate readily[37].
>
> ANSTO is not doing research on welding per se. However, the safety of our nuclear plant depends on the structural integrity of our plant components, many of which contain welds. We do research on the remaining life of plant and welded structures and have used our nuclear science and technology background to work with major Australian companies in energy industries[38].

The PSR (in this case is ANSTO) thus has its own codified information transaction within its own organization entity. The main type of codified information transaction (for ANSTO) is everything dealing with problems of welding in the safety of a nuclear reactor. Moreover, the information, which is gained from this expertise is used to strengthen the capability of

[34] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[35] Interview with Dr. Frank Barbaro, BHP Steel Division, October 4, 2000.
[36] Interview with Dr.Colin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.
[37] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000.

ANSTO to deal with problems related to welding not only for one department (Material Division) but also for the entire ANSTO organization[39]. The information taken from this collaborative network is distributed to other department of ANSTO and this needs another layer of information transaction, which has a relationship with the web of collaboration of CRC WS[40]. The APIA also transacts information by using special codification based on their typical problems (dealing with welding in pipeline applications). The following quote from the APIA Executive Director illustrates this point:

> I would say, our information transaction is very much in the pre-competitive stages of development. We identify areas of research interest, well especially, such as the owners, contractors, and some of their major engineering companies. Some of them are suppliers. We have representatives from all our major owners of pipelines, we have contractor representatives, we have engineering companies representatives and some suppliers as well. And we sit together, to identify through our committee structure, collaborative opportunity, which we then seek funding for. And an appropriate organization to do that work for us, be it research, or be it study at or be lobbying efforts.
>
> We are the catalyst to identify areas of our common interest and then we get industry, government and competitive business at once. So we do not get involved in competitive issues, we get involved in issues where we believe there is benefit across the whole pipeline industry[41].

The APIA dominates information and its codification related to the pipeline application of welding technology and techniques, as the APIA Executive Director points out in the following quote:

> We have been involved to a degree in this pipeline program since 1996. We concluded the benefit in it to the industry. So APIA executives came and said we would become a core member of CRC and we would rather become the lead group of the pipeline program, because we can support that pipeline research and we have the best mechanism to ensure the delivery of the outcome of this research to the industry[42].

[38] Ibid.
[39] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000.
[40] Ibid.
[41] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[42] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.

The interesting thing is that APIA functions as information provider, thus, for APIA, the more members they have, the more attractive they are, given that more member will increase their information capacity to be able to solve other members problems[43]. For APIA, the policy is to open membership as wide as possible in order to widen their information-transaction dimension, and to enable them to solve more complicated problems from the industry[44]. A good example is the huge business sector, the Australian Gas Limited (AGL) which joined APIA membership after seeing the benefits that this organization could expect from APIA[45]. The inclusion of AGL to APIA membership will increase APIA information capacity and its codification and allows for an increase of APIA total capability in conducting research[46]. Thus this will attract more organizations to join this consortium.

The role of the APIA Director in this process of information transaction (within the APIA consortium) is interesting because the APIA Executive Director, is the only agent, who has access to all kinds of information, as indicated in the quote below:

> When the nature of the information is more commercially sensitive, without a doubt we use this model [see picture below]. Because our members place their trust in me, in communicating and knowing that I am not going to, you know, so I will have to judge what kind of information I can talk to other people. In other words they trust me to be their repository of their information. And that works very effectively[47].

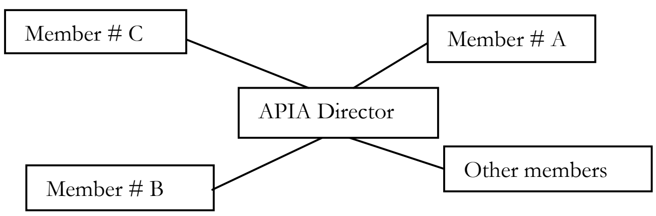

Figure 6.2. Communication method in APIA member # A can communicate to member # B only via APIA Director. Source: Author, based on interview

[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.

The type of information thus determines the process of its transaction and this is indicated by the following quote from the APIA Executive Director:

> There is often a sensitivity of information transaction between parties, so the actor the go-between, has to make a filter. And, as we have agreed our position, what tends to happen is the interaction between these partners increase independently. And, we all then becoming equal partners, and, it depends on the information issue[48].

In APIA, the role of the APIA Executive Director is thus very critical, see figure 6.2. The APIA Executive Director has to play as co-ordinator in the mixing of information for this particular APIA web of collaboration. The APIA Executive Director has to determine what kind of information should be passed through to others, how to do this, and why[49].

The other industry consortium as participant of similar to this APIA is WTIA. Both the WTIA and APIA, conduct the process of information transaction in a very codified method[50]. In WTIA, the organization has the so-called Science Technology Manager (STM) in each of the states of Australia[51]. The STM is a collection of experts in a particular discipline, and they are also capable of providing contact to other technical entities which are in a position to solve problems dealing with welding. There are in total six STMs nationwide, who can help the WTIA members to solve their technical problems. Every STM is an expert and well-experienced people in the field of welding and joining. They can pro-actively link between industry, especially Small and Medium Enterprises (SME), centres of technical excellence and knowledge and research and other organizations. The STM is augmented by the National Technology Advisors (NTA) who has the responsibility as gatekeeper for

[48] Ibid.
[49] Ibid.
[50] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[51] Ibid.

WTIA[52]. There is also the National Hotline Engineer (NHE), who will provide a rapid response to telephone, e-mail, and facsimile enquires on welding and joining technologies[53].

Furthermore the WTIA also develops the Technical Panels (TP) and there are in total 15 TP[54] around Australia. The TP is a group of experts in their particular field related to nearly all aspects of welding technology and techniques. This group of people is ready to help the industry in solving problems. The STM, NTA and TP can help to de-codify the information, given their nature of work, which is very interactive and problem-oriented based. At the same time, these three entities (STM, NTA and TP) can help re-codify the information whenever necessary. The CRC WS with WTIA as participant is a formal collaboration and thus codification of information transactions are very common and this formal codification is manifested by the roles of STM, NTA, and TP.

An example of the process of de-codification and re-codification of information is the development of the Technical Notes (TN) developed by TP. The TN is the guidance note, which lists all the related solutions of all possible problems encountered by the industry. The members of TP and STM will list all the problems from the industries (including all the used codifications) and determine the used codification, and the members of TP and STM will discuss how to develop a new kind of codification (de-codify) which can be used by the users and solve problems. Then these new agreed codifications will be put into a guide (re-codification) and distributed to other members (who previously have had no problem) to

[52] Ibid.
[53] Ibid.
[54] List of WTIA Technical Panels is given in Appendix 2.

solve their possible problems in the near future. The following quote from the WTIA Executive Director illustrates this point:

> We have things like our technical notes. These technical notes are for all members from, anybody who is even wondering how to start, to experts. For many years WTIA has produced technical notes on a whole array of subjects. And these technical-notes are drawn out by our technical panels. We have fifteen technical panels, all the experts in Australia, who work in a voluntary manner for the institute. And these technical notes are continually updated. In terms of moderate, there are numerous ways to go. Because our clients can be discussing things with our state technology managers, our clients could be coming to our seminar, our clients could be coming to, what we called colloquiums, where we get all industry together and talk about problems. There are many ways for solving these problems. For example: FAQ, frequently asked questions and best practices, our technical notes and technology demonstrations. We show people and demonstrate the technology, technical guidance notes, seminars, conferences, experts and other technology tools. For standards, many of them are of international standard, which you use information in there, which gives guidance to people. So whether you are an expert, a moderate, or a beginner, those standard technical notes tell you exactly what you should do[55].

The previous quote implies that the process of information transaction within WTIA is with the use of the "agreed" codification. That is done by combining some inputs from TP, NTA and STM. All will be given in the format of those TNs, so the information is thus in a very well codified format. In addition, some other operational formalized codifications developed by their STMs are available. Nearly all trouble-shooting concepts in welding practices are available in these TN (technical notes). The members of WTIA use the well-codified information in the TN within their practices. In case there are some more problems, the WTIA experts are available for help, to solve extra problems. As noted, the TN itself has been made by an interactive participation among experts of WTIA, supported by Ozweld Technology Support Centres (with membership of various organizations), plus another codified information transaction process at SMART-Tech Net (see next page), and some inputs from users of the TN. This creates a kind of comprehensive, commonly understood "codification" for the entire members of WTIA. Therefore, there is also a reflexive feature of the Technical Notes, in order to anticipate the dynamics of the sub-systems. To enhance the level of understanding and to diffuse the usage of this codified information, some more seminars, symposiums and the so-called colloquiums are being organized[56]. These can further increase the level of reflexivity of the system in anticipating the very dynamics of activity of sub-systems underneath, as the WTIA Executive Director has pointed out in the following quote:

> We make a number of flexible mechanisms of forums available to transfer the information. In March 2000, we held a big conference. It was the first in the world. So we had big and small companies, we had universities, and we had overseas partners in that conference. And we can, we come up with an action plan to sort out problems faced by industry[57].

In fact not all 315 members of WTIA and Ozweld consortium are participants of CRC WS[58], but WTIA disseminates the information to all the members through seminars and technology conferences organized regularly by WTIA (from a WTIA perspective they call this technology transfer program)[59]. WTIA also disseminates the information to their "alliances" from overseas, in return for another type of information for WTIA's benefit.

As mentioned earlier, the other codification of information transaction used in WTIA is the so-called SMART Tech-Net program. This is a well-codified information transaction, where some very specific people are being grouped into a very specific group to deal with very specific problems[60]. There are in total 18 SMART groups[61]. In WTIA, under the SMART Tech-Net program, there are several complex multi layers of information transaction and

[55] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[56] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[57] Ibid.
[58] Ibid
[59] Ibid
[60]Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[61] The list of this SMART group is given in Appendix 2.

some more sub dynamics within the WTIA organization. Most of the layers of information transaction, are transacting the information in a codified communication format. The following quotes from the WTIA Executive Director illustrate this point:

> Now, what we say is, we divide the companies that where the experts come from, to SMART group. All the experts are clients, but they are also already well-qualified people, well-experienced people. So those partners want to work together to achieve result, sort of benefit, of each of them. So you need to search something good. We, with the big companies, we have our SMART group. It is a smart group. So we set up a SMART Power Generation, SMART Pipelines, SMART Petrochem.
>
> And these groups have been very successful with those industries in working out their needs and also between the institute. Our full time staff and network can offer the solutions. In the next new project, we are going to expand the concept of this SMART group across many other industries[62].

The above quote implies that each industry is grouped into each particular SMART Group and can only deal specifically with that specific topic (type of information), this reinforces the fact that the process of information transaction is well codified.

All information submitted by different participants with different codification will be put into the "Information Mixing Pot"[63]. However, in mixing up this information from both external and internal sources, for each participant of CRC WS, it will have two barriers. The first one is caused by the reluctant behaviour of each participant to accept information from outside and the second one is that within the organization itself, it is difficult to mix information with other information[64].

In this Information Mixing Pot, the elements of each participant, which has capacity of information to deal with problem solving are combined within a platform in order to discuss

[62] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.

and propose the solution of the problem. Therefore, the existence of an Information Mixing Pot is required because the submitted information is still within it's own codification which is obviously different among participants.

The process of mixing the information in the Information Mixing Pot produces a set of information, which is used to control the entire CRC WS program's operation. It must be noted that during the process of information mixing, within the Information Mixing Pot, all types of information that are involved must somehow avoid a conflicting competitive issue especially among participants. The following quote from a member of CRC WS Board of Directors (who is also APIA Executive Director) illustrates this point:

> You have got the Central Core (see figure 6.3), if you want general information, the type of research, you know, you have got a very general research. And as you work your way out, it becomes, the final outer ring, it is the market. It becomes more and more, commercially sensitive, the more you move out.
>
> And so what we try to do, is to work within this general framework, or at the centre ring, until we know that we can no longer co-operate[65].

Please see print copy for Figure 6.3

Figure 6.3. Market's interest in circles of communication. Source: from Dr. Beasley's Interview.

The other function of the Information Mixing Pot is to determine the codification to border between the competitive issue and pre-competitive issue, and this is one of the most important matters in order to guarantee the success of CRC WS collaborative research. The new created information from the Information Mixing Pot must be understood by all

[63] Information Mixing Pot is a virtual pot where all the information are mixed and processed. In practice this happens in meetings and discussions, which are attended by all participants. For detailed explanation see again section 5.4.
[64] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

participants. It is the task of CRC WS to play the role of translation media[66] which has to "translate" all the codifications of the information in this CRC WS so that all participants can "understand" each other. Moreover this process of information mixing will happen in continuity and thus this translation media will always be required.

In practice, the manner for conducting these efforts basically uses a formal regular meeting which is conducted on a monthly basis for the Board of Directors (first level) and is followed by weekly and on an occasional basis formal irregular meetings between researchers and program's leaders (second level). These are attended by representatives of all involved participants[67] as the CEO of this CRC mentions:

> Yes, we have a quarterly meeting on all projects. And I am trying to meet all the participants once every quarter. We have about 25 projects, so at least, once every month, six to eight per month possibly. These meetings maybe in Perth, maybe in Melbourne. And we still have irregular meetings beyond these regular meetings[68].

In the process of information transaction in this CRC WS, the role of CRC WS Director is important. In relation to the function and task of translation media, the Director of this CRC WS has to play as a translation "agent", who is supposed to translate the codification from different participants to other participants. The Director of this CRC can conduct this task through formal meetings and augment them by irregular meetings if necessary[69]. In particular the Director of this CRC WS has spent a lot of time working with industries as well as with government agencies and has formed many relationship with several societies and research entities involved in this CRC WS collaboration program[70].

---

[65] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[66] This translation media is also called translation regime. This concept was introduced in chapter 5, and will be further discussed in section 6.3
[67] Interview with Mr.Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[68] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

Beside its main function as a "controller" of the entire information transaction in CRC WS, the type of information produced by the Information Mixing Pot, is used to create innovation. In fact the innovation created may be radical for there are many variations of available pieces of information within this Information Mixing Pot. This innovation is necessary for all participants within a web of collaboration. For university participants this innovation can be used to create a new kind of curriculum in the university education program which will be more suited to solve problems in industry. One way to achieve this objective is to introduce the problems from CRC WS to the postgraduate student. For example: the PhD thesis material for a PhD student in CRC WS education program is coming from the industry[71].

The industry is also getting more innovative in doing this collaborative research work. The following quote was given by an Executive Director of APIA when being asked, are you getting more innovative:

> Yes, without a doubt. And, part of this is, in getting the multi best practice in producing local pipeline. And, without a doubt, the Australian Pipeline Industry is continuing to lower its cost in the construction of pipeline. And part of that reason is the use of research through this CRC. So that is absolutely essential, we have been collaborative with this CRC and in the future we are continuing to be collaborative[72].

The Information Mixing Pot delivers a new type of information which, can be used by an industry participant to solve problems and to create new-innovation. The following quote is from an Executive of BHP Steel, who was also a Project Leader of CRC WS, when asked, for what and how do you use the information produced by this collaboration, i.e whether it was for innovation or for technical problem solving, or both.

[69] Ibid.
[70] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

> Well, for both. Mainly problem solving. Well, in particular, the meeting from where I came today, we have had a problem with maintaining a system of weld quality in some of our strips joining processes. And with funding research in this CRC we have come up with new innovative techniques to assess weld quality, to really solve problems that we have got there. The other area of research for innovation we really exploring is the requirement of welding in high strength steel. For example research for high strength pipelines. So, we in this CRC have been involved in both problem solving and innovation[73].

Besides information for innovation in order to deal directly with problem-solving, information for innovation can also create many more jobs for industries, as indicated by an Executive Director of WTIA in the following quote:

> Yes, we create innovation all the time. Normally, when academics talk about innovation, they tend to talk about something really fantastic. For us, innovation can be a very basic thing which creates a lot of work and may increase our productivity[74].

Thus innovation offers many benefits to participants of this CRC. Another example is the Defence Science Technology Organization (DSTO), as a participant of this CRC, for instance, it has got the idea of building a Light Weight Guided Missile Frigate (FFG), on the basis of high strength steel, after getting inputs from CRC WS[75]. The CRC WS's idea is to weld the FFG in a completely new way, which does not increase the weight of the engineering design.

From the previous discussion it can be concluded that the information submitted by participants can be brought and disseminated to other participants through this CRC. And by mixing this information with that of others, it may produce some benefits to participants,

[71] Interview with Mr. Bradley Glass, recipient of PhD scholarship, CRC WS, November 10, 1999.
[72] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.
[73] Interview with Dr. Frank Barbaro, BHP Steel Division, October 4, 2000.
[74] Interview with Mr. Christopher Smallbone, Executive Director of WTIA, September 4, 2000.
[75] Interview with Dr. Allen Beasley, Executive Director of APIA, October 25, 2000.

which can be used to solve their problems and create innovation. The next subsection discusses the role of the information system in the process of information transaction.

6.2.2. THE INFORMATION SYSTEM AND INFORMATION TRANSACTION

In order to support the process of the information transaction among participants within the collaboration, the CRC WS has developed an Internet based information system called Integrated Project Management Information System (IPMIS) which will enhance the process of information processing in the second level especially for the purposes of task's progress monitoring and evaluations. (CRC WS Annual Report 1998/99, p 30) The projects in this CRC WS, are executed together and the supervision is given by allocating a representative from all involved organizations in the research sites, which are linked by this IPMIS network.

The process of transacting the information in this CRC is strongly supported by IPMIS. This Internet based management information system was previously developed and used by BHP[76] and then it was adopted as CRC WS main information exchange system (after being expanded and upgraded). This kind of (management) information system enables all participants to monitor the state of progress of all projects from inception to completion. The following quote from the CEO of this CRC illustrates this point:

> Well, this IPMIS system is quite powerful. I have found out that, for example in formulating a project for this year to researchers in the whole of Australia, we were looking at IPMIS together at the same project proposal, and we were working on it together, while they were looking at their computer screen [77].

[76]Interview with Dr.Frank Barbaro, BHP Steel, October 4, 2000.

[77] Interview with Dr.Collin Chipperfield , CEO CRC WS and founder of CRC MWJ, June 24, 2000.

Moreover, without the IPMIS system it will be difficult to transact the information with a participant from overseas, as the CEO of this CRC has pointed out, in the following quote:

> In terms of management, especially the ability of overseas parties, that we have given access to IPMIS, I think they would miss it very much. Also, in terms of management of the entire project and the ability of the Board of Directors to oversee the projects it will be much more limited without IPMIS[78].

The above quote implies that when IPMIS is not available, the codification coming from overseas will not be able to be included in the Information Mixing Pot. It could be, but the process would be very slow, while in the meantime that codification might have been useful for the entire web of collaboration. As noted, this IPMIS was previously introduced by BHP. This move of BHP is very reasonable for in the current world economy, Internet and Intranet solutions are providing good electronic collaboration options that can be extended to incorporate outside suppliers and vendors as well. Thus IPMIS can provide an e-solution to the project execution. The goal of this IPMIS system is to help in the sharing of data with customers, suppliers and sub contractors in order to better make use of external sources, meet customer expectations and quickly identify new product opportunities. The IPMIS so far has been operating as a good communication platform for the process of de-codification and re-codification of the used codes[79].

More over, the IPMIS may help create a situation where information from one part of the organization can readily be made available to other parts, a situation, which an information perspective suggests, is highly conducive for creating innovation. IPMIS enables an increase in contact between all participants in CRC WS, from researchers in UoW to users from WTIA and APIA members. This is when IPMIS capability is being enhanced to cover all

[78] Ibid.
[79] Interview with Dr.Frank Barbaro, BHP Steel, October 4, 2000.

research activities, including allowing researchers to share the research work together under this platform of information transaction. Such a situation has not yet completely happened, but is in the process of realization[80].

To summarize, it can be concluded that the entire CRC WS collaboration is driven, coordinated and managed by information processing in the Information Mixing Pot, within the CRC WS. The Information Mixing Pot plays an important role in coordinating and mixing the information within the CRC WS collaboration. This is important because how these bits of information relate to each other with their suitable codification is the crucial element in the process of both technical innovation and the solution to technical problems. The type of information being transacted is a technical type of information mainly related to problem solving in welding areas from many applications in the industry, which previously came from BHP as the initiator of the collaboration. This furthermore triggers many more applications of welding produced from the process of solving these problems themselves by the research providers.

The technical type of information dealing with welding that applies to the pipeline industry has thus driven, coordinated and changed the dynamic of the entire collaborative research entity. The main direction of application is pipeline application, which ranks first, followed by other industrial applications such as sealed structures for nuclear building, and other issues. The next section discusses the ability of this CRC WS to play as a translation regime and how it determines the relationship among participants. A closer investigation of what happens in the Information Mixing Pot will be explored.

[80] Interview with Dr.Frank Barbaro, BHP-Steel, October 4, 2000.

6.3. THE "NEWT" MODEL IN ACTION. CASE STUDY 1, THE CRC WS

This section discusses the application of the Newt model to explain the process of information transaction in case study 1, CRC WS. This model is used to analyze the establishment and process of information transaction in the operation of CRC WS.

The Newt model considers the CRC WS collaboration as an arena of information transaction among participants. This process must be started by a particular type of information, which is submitted by a particular participant and the entire process of information transaction is conducted within a particular codification (in the method of information transaction). Under such circumstances, a kind of relationship exists between participants in the collaboration and, as the Newt model suggests, this is based on the master to slave relationship. This relationship may contribute to the success or failure of CRC collaboration. In the previous section it has been described how BHP started the process of information transaction.

The main factor, which triggers the entire collaboration has been the information provided by BHP. This factor has attracted many participants and has started the collaboration. The establishment of this CRC from the Newt model will be explained by using the analytical figure 6.4.

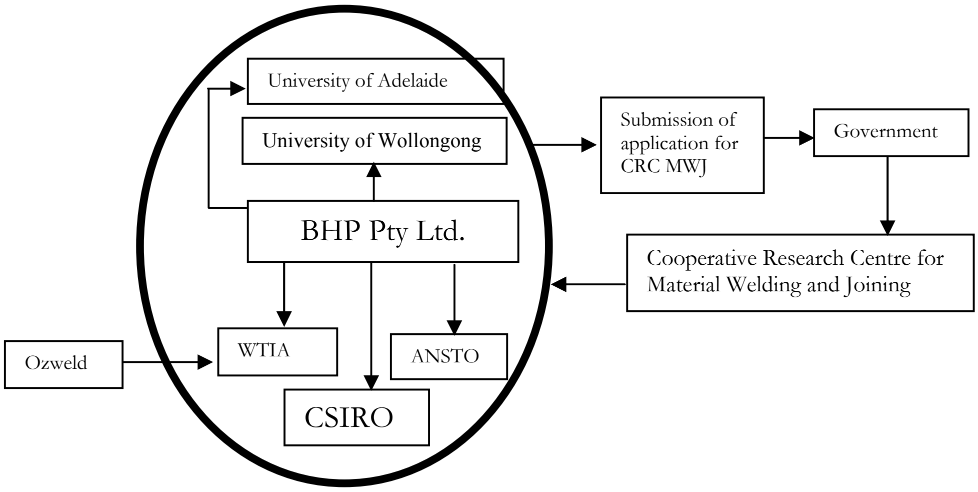

Figure 6.4. The information flow for the establishment of CRC MWJ. Source: Author.

BHP is at the centre of the organization for information activity and for the establishment of this CRC, because the type of information provided by BHP has triggered this collaborative research partnership. BHP was interested in the technical solution to the problem of welding the steel (its welding time), because for BHP this information is critical to the direct success of its business. From this type of technical information, another type of technical information is expected to be derived. The WTIA, is in such a position to be important in this matter. This organization can estimate to the solution of the problems faced by BHP by collecting bits of information coming from the organizations which are members of the consortium (figure 6.4), because these members have previously dealt with this particular welding business. This information is required by BHP, which is faced by an increasing complexity of problems related to welding and joining. Then, this type of information (about welding and joining) is submitted by WTIA, as one of core components of the establishment of CRC MWJ, to the first five participants of the proposed CRC MWJ (figure 6.4). The information provided by BHP attracted the CSIRO, ANSTO and two universities. These organizations saw the need to join in the information activity because they needed to solve their own technical problems by mixing their own information with the information that is provided by BHP.

These five participants mixed the information provided by WTIA (and Ozweld) with their own internal information and finally this new type of information was submitted to the government as a proposal for the establishment of CRC MWJ. The government approved the proposal (figure 6.4), and the CRC MWJ was established. This new organ CRC MWJ will become the new place for mixing several more types of information from all participants, for the benefit of all participants: that is for solving their technical problems and possibly to create innovation.

After the application was approved, more Australian industries and universities joined the CRC MWJ. Another industry consortium, the APIA, later joined the CRC MWJ (after it become CRC WS) because of its intention to take a lead and get more involved in pipeline research activities and by this action APIA can increase its level of excellence in dealing with all problems related to the pipeline industry in Australia. This is very beneficial for APIA, for this organization has to profit its members in terms of consultancies for solving their technical problems.

In fact such a reason applies to both industry consortiums (WTIA and APIA). Both organizations apply a membership fee to their members and these organizations (WTIA and APIA) need to give service to their members. Joining or promoting the establishment of CRC, will enabled them to accumulate all the information capacity of all research entities in

Australia in these two particular fields (welding and pipeline issues). Analytical figure 6.5 depicts the CRC WS operation:

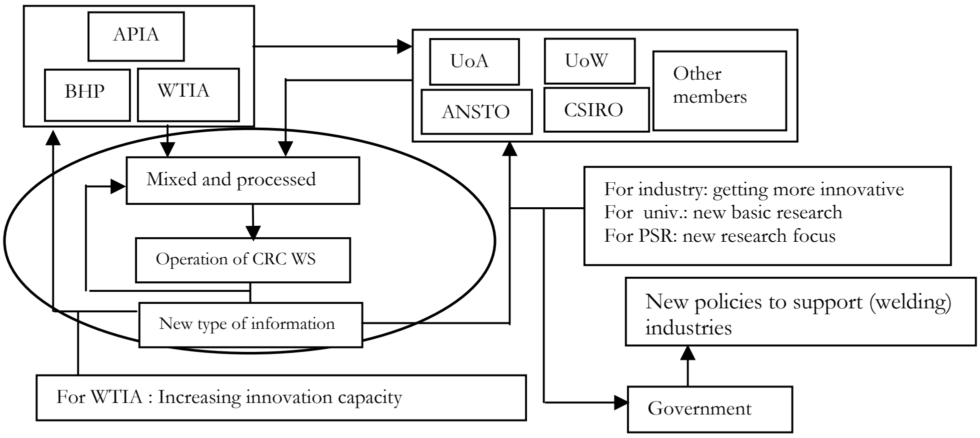

Figure 6.5. The operation of CRC WS from an information perspective. Source: Author.

The previously mentioned "Information Mixing Pot" (see page 149) is the box "Mixed and Processed". This is a virtual place where all the information is submitted, translated, de-codified and re-codified, when necessary. The information produced from the processing within this box is used to operate the entire CRC. This information has to be fed back to the box "Mixed and Processed", from some new inputs from all members. This information can also produce new innovation for members. Utilizing the membership link also provides the next level of information exchange by an industry consortium such as APIA and WTIA. In many cases, there are some specific technical problems that cannot be extracted from this "new type of information", because in some cases the technical problem is a mixture of some other technical problems and is sometimes coupled with business problems. Thus, there is a need to develop a new kind of codification by using an Information Mixing Pot in order to find the solution. Using the combination of all these efforts, the CRC WS is in a position to become an excellent arena of information transaction for dealing with nearly all problems related to welding in industry.

The channel for the information exchange in CRC WS is enhanced by strong support from WTIA (plus its relationship with Ozweld), which provides a technology transfer program in the form of technical conferences, seminars and the like in the field of welding techniques and technology. Another participant, APIA, further supports this effort by conducting similar services in welding technologies and techniques application specifically in pipelines. The PSR's contribution to the collaboration is by providing qualified personnel, and the same applies for the university participants (University of Wollongong and University of Adelaide). The PSR conducts the work in the form of contract research and the universities work in the form of contract research and PhD or master level theses sponsored by CRC to solve the (technical) problems, which are actually coming from the industry. Projects are evaluated and the results are sent back to the information's "Mixed and processed" box (figure 6.5). This information is then labelled "new type of information" (figure 6.5) and this is used as a new input in the information processing to control the second loop of the CRC WS operation.

This process is repeated (the boxes within the ellipse in figure 6.5 are working continuously) until the expiry of CRC WS's contract with the government. Basically the "new type of information" produced from the Information Mixing Pot is the most important thing in the course of the program. This is the information which can be used by government to draw up some new policies related to the welding industry in Australia. For example, this information is used to evaluate and to improve the CRC program, to better identify the pattern of Australian industries in the field of welding and joining for anticipating international competition[81]. For the industry participants such as BHP, this type of information can help

[81] Interview with Dr. John Boyd, Member of CRC Committee, DIST, October 22, 1999.

them solve their technical problems and for better identification of both current and future market of their products[82]. For public sector research agencies such as ANSTO, DSTO and CSIRO this new type of information can help them open to a new dimension for new kind of research in welding technology[83]. And for university participants such as UoW and UoA, this type of information can help open up a new focus for basic research[84]. For industry consortia such as WTIA and Ozweld, this new type of information enables them to increase the information capacity of the members of their consortium[85]. The new type of information created will be used as the trigger for the next process of information transaction. As has been discussed in the previous section, the type of information will always be under a particular codification, and the process of transaction will also be codified. There is thus a need to make all participants "understand" the new created information, and in order to achieve this objective the Newt model proposes the usage of the translation regime.

The following figure 6.6 pictures the position of CRC QW as the translation regime in the web of collaboration among participants from industry, university and PSR agencies.

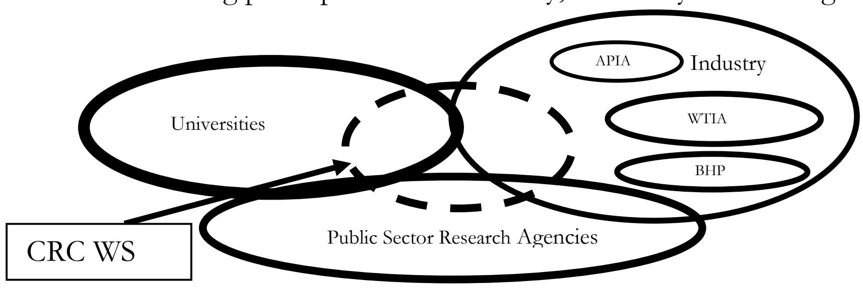

Figure 6.6. The CRC for Welded Structures (circle with dashed line) as a Translation Regime. Source: Author.

[82] Interview with Dr. Frank Barbaro, Chief BHP Integrated Steel Division, October 4, 2000
[83] Interview with Dr. Adam Jostsons, Director ANSTO Material Division, June 1, 2000
[84] Interview with Mr. Bradley Glass, PhD student Fac.of Mechanical Engineering, Univ.of Wollongong, recipient of CRC WS scholarship and participant of CRC WS education program, November 10, 1999
[85] Interviews with Dr. Allen Beasley, Executive Director of APIA (October 25, 2000) and Mr. Chris Smallbone, Executive Director of WTIA (March 8, 2000)

How this CRC WS works as a translation regime is discussed in two parts. The first part discusses how each participant is limited to its own codification in dealing with information transaction. The second part discusses how the regime can "translate" the codification (of information and its transaction) from each participant to other participants. This second part is explained by the use of an analytical model, which is called a Spider Diagram (see later in figure 6.7).

The industry participants, led by BHP, are transacting their information in their own codification. The same applies for industry consortia such as APIA and WTIA. The existence of representatives from different members such as major owners, owners, contractors and engineering companies, reflect the need to deal with a complex system of codification.

For APIA, this organization is giving service to its members through consultation and as an information provider. A company that has technical problems can join APIA[86] and APIA will help this member by providing a solution to problems. The type of information is mainly technical information dealing specifically with the pipeline applications. The process of transacting this information is conducted in a formal manner. The type of information which is transacted brings into existence various layers in the codification of the process of information transaction within APIA. This is because APIA has in total 240 corporate members and each of them has its own codified process of information transaction (caused by a particular transacted type of information). With its higher capacity to conduct research APIA is able to increase its information capacity in dealing with more problems. It also

[86] In the year 2000, APIA annual membership fee was A$ 1,000.

increases its competence to develop a better codification which enhance the information transaction among its members.

The APIA Director acts as a translation agent who de-codifies and re-codifies the information when necessary. In reality this process is conducted by organizing a formal regular meeting with APIA members. As a consortium with many different members APIA has several layers of information transaction. WTIA has a similar situation. The WTIA has developed a mechanism to enable itself as a big organization with many different members to deal with different information codification and different layers of process of information (from members).

It can be concluded that these two organizations, as core participants of CRC WS, have their own codified information in dealing with problems in their activities. They both have multi layers of sub-dynamics (of information codification with its codified process of transaction, from each member) along with their own dynamics (of the entire organization). However, they have been able to anticipate both dynamics (their own dynamics and dynamics in those system underneath) so it can be concluded that the codification they have developed is reflexive against those dynamics.

The process of information transaction within ANSTO deals with a similar situation. The sub dynamics are from different departments of ANSTO which are involved in this collaboration. The process of information transaction used is in a very codified format (e.g formal meeting). So in each of the previous three organizations, there is always an active sub dynamic within their codification (of information and its process of transaction) and all of them can be categorized as well-codified. The processes for transaction of codified information are conducted in a codified form. To summarize, table 6.1 (see next page) lists the key codification used in the information transaction for each member of this CRC WS.

To visualize how the CRC WS can play its role as a translation regime to execute the process of de-codification and re-codification of each participant, the author has developed an analytical figure, which is called the Spider diagram (figure 6.7). This diagram visualizes the way CRC WS as a translation regime may move from one entity to another entity with different dynamics. The position of CRC WS among the existing sub system and sub dynamic within the web of collaboration of CRC in the analytical spider diagram is given in figure 6.7 as an ellipse with a thick line. This ellipse is located at the 'body' of the spider (at the centre). Meanwhile each spider's leg represents the dynamics of each participant of this CRC (figure 6.7).

The spider diagram given at figure 6.7 takes only 4 participants as an example. In reality there should be all 12 participants, but with 12 participants in one picture the spider-diagram would be less visible. It is clear that there are several sub-systems and therefore sub-dynamics in the system.

Table 6.1. Summary of key codification used for information transaction by core members of CRC WS. Source: Author (compiled from interviews and CRC WS annual reports).

Name of participant	Main type of Information	Key used codification for information transaction
WTIA	Technical type of information dealing with multi role welding and all related problems.	Formal and very strong codified information transaction. Service is available nationwide ONLY to members. It is membership fee based. Service is given in Technical Note which is a very well codified information package.
APIA	Mainly technical type of information dealing specifically with problems with welding in pipelines application with a strong pre-competitive character.	Mixture of formal and informal with limited codified information transaction. Service is available nationwide ONLY to members. It is membership fee based. Service is given via the Director.
BHP	Specific business-industrial application of welding in steel plates especially the welding time.	Formal information transaction, with a competitive and strong business oriented information exchange[87].
ANSTO	Specific information exchange related to welding application in construction of nuclear reactors.	Formal information transaction with non-competitive character in information exchange[88].
Univer-sities	General type of information to solve all problems related to welding.	Formal information transaction. However, application of the information may increase competitive values of university especially in terms of teaching quality and percentage of graduates taken up by industry. It has, thus a limited competitive character[89] in information exchange.

The existence of these sub-systems (with their corresponding sub-dynamics) are results of different codified information, which forces the creation of different information transactions.

[87] BHP as a business institution considers all information related to industrial application as having commercial values. Thus for BHP information transaction must be treated as part of business activities with possible interest for BHP competitors. Interview with Dr. Frank Barbaro, Chief BHP Integrated Steel Division, October 4, 2000.

[88] As a public organization, all information related to research activities are considered as public domain. The information can be considered as having commercial values once it is transferred to industry for potential commercial applications. Interview with Dr. Adam Jostsons, Director ANSTO Material Divisions, June 1, 2000.

[89] The increasing need from universities to take more funding from industries for their research activities has created a kind of competition among universities for funding. Moreover the CRC application itself is based on competitive advantage of university on particular fields. Interview with Dr. Geoffrey Vaughan, Member of CRC Secretariat, DIST, June 9, 1999.

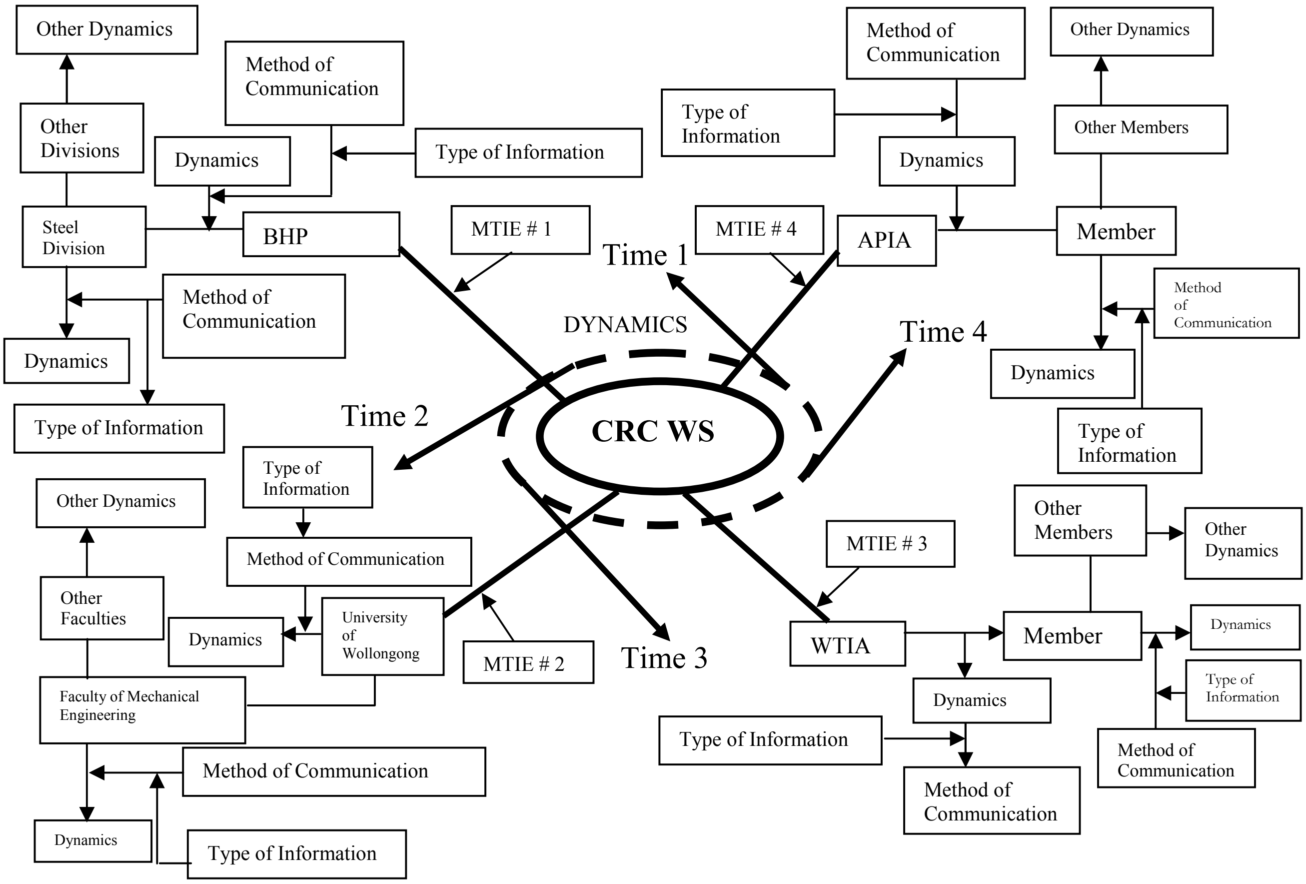

Figure 6.7. The position of CRC WS among sub systems and sub dynamics of its members.
Note: MTIE means: Main Type of Information being Exchanged. Source: Author.

Consequently, each participant will have its own dynamics. For organization with members under its group such as WTIA and APIA the problems are more complicated given that these two organizations still have to face the dynamics of these members. There is need to develop a translation regime to allow better exchange of information with different codification.

This translation regime must be reflexive and able to 'read' the dynamics in the entire system including all those sub-dynamics. The CRC WS is playing this role properly. The CRC WS helps to translate the codification of information used between the users of technology (mainly from industry) and the provider of the technology (the public sector research agencies and universities). The method is, firstly: to make them develop their own codification of information transaction and by adopting all the codification of information transaction used by all the participants. Secondly, to try to develop a new codification of information (re-codification) transaction for the industry and other participants which is better understood by industry. This re-codification is important given that CRC WS is a formal collaboration. Moreover, this is particularly important because main problems and ideas normally come from the industry. Besides, industry is actually the main target of CRC WS.

The previously described process happens in reality through regular meetings conducted by representatives of CRC WS participants. Each representative would describe the problems by using own codification, for example representative from ANSTO, would use codification as a public sector research agency which all information is considered as public domain, representative from BHP as industry would consider information as having commercial values and so on. The regular meeting at CRC WS is a process to generate a common codification that can be understood by all participants.

In figure 6.7, the ellipse shown by the thick black line is the CRC WS as a translation regime. The ellipse in the dashed line depicts the motion of this translation regime to the four corners representing, in this example, the dynamics and sub dynamics of codified information (and its process of transaction) of four participants. At Time 1, the translation regime will move to the top left corner. The main task is to detect the dynamics of the codification of BHP. In BHP there is the BHP Steel Division which is involved in the CRC WS, however in practice, most of the work and work results, are distributed (and diffused) to the other divisions of BHP as well. Each division has its own dynamics, given they have different types of information being transacted and thus they have a different process of information transaction. With the BHP Steel Division, the MTIE (Main Type of Information being Exchanged) # 1 is: the need to have solution of welding time in steel application (see also table 6.1).

At Time 2, the translation regime (which is the spider's body) will be doing the same thing (the spider's body moves in a counter clock-wise direction), this time to the UoW, Faculty of Mechanical Engineering (bottom left corner). With the university people, MTIE # 2 is all possible technical solution for the previous MTIE # 1 since the university is used as an incubator of technology for the CRC WS (table 6.1). The solution for the BHP problem may be found and moreover this BHP problem may give university participant ideas for new kinds of problems and thus new research agendas. MTIE #2 is thus a mixture of the answer to MTIE # 1 and several new types of information generated by mixing MTIE # 1, its solution and new ideas from university participants.

At Time 3, this spider's body will go to another participant, for example WTIA (at bottom right corner) and in this case the MTIE # 3 will be welding technology and its technical application to increase information capacity for the welders (table 6.1). The solution of BHP problems may be diffused here and may find another application for welders.

Finally, at Time 4 CRC WS translation regime may go to another participant as for example APIA and there will be a process of information transaction by using codification of information which is used by the APIA entity (at top right corner). In this case the main type of information being transacted (MTIE # 4) is welding technology for specific application in pipeline construction (see table 6.1).

For each of the Time # n (n = 1 to 4), the CRC WS translation regime moves to each of the dynamics, detects the dynamics and (when it moves to other dynamics) it is able to reflexively adapt to the new dynamics and translate the codification from the previous dynamics to these dynamics. This is the mechanism which allows reflexive and adaptive behaviour within the system.

In the development of such a reflexive, adaptable, commonly understood codification of information the role of the CRC Director is important. The Director is the person who will translate the codification of information from one participant to others. The Director is the agent who operates this translation regime and she/he must be able to detect all the existing dynamics in the system and sub system of the participants. The Director, for example, must be able to know exactly where to find the matching of research information for a particular problem faced by an industry. Thus, the Director must understand the dynamics of all participants. If these are industry consortia, the Director must know the dynamics of the members of the consortium, so that she/he can appropriately link the industry with other participants that have relevant solutions for the problems. To fulfil such tasks, important requirements for a CRC WS Director are a strong background in working with industry and having many links with industry. In the Information Mixing Pot (figure 6.4) the Director will act as catalyst to develop new required codification for information transaction with a different background. In this way, the Director will also act as an agent to allow a possible appropriate selection of several operating sub-systems within the system so that a controllable process can be achieved.

The codification of information can be developed as such so that all participants can use and apply it to solve their problems. The role of the Director is as translation agent for this process, which helps each member to understand the codification used by others.

The Internet information system has been widely used to assist these tasks. In CRC WS an information system, called IPMIS, assists the Director in doing this job as an agent in the translation regime. The Director should be able to function as the translation-agent because he/she is someone who is supposed to master nearly all codification involved and used in the information transaction. The Director also functions as information repository to help identify the codification by participants and translate them to other participants.

The Director's view in developing suitable codification of information is important in order to determine performance of a collaborative program and the success of the process of the information transaction. Since the Director is the head of the CRC and has the capacity to determine the CRC's policies, there is a strong role for the CRC in functioning as a translation regime for the entire collaborative program. The codification of information can be adjusted in the corporate meetings by involving all representatives of participants of the CRC-WS. During this meeting a new Information Mixing Pot will be created (which means starting the second loop in ellipse in figure 6.4) where a new codification of information will be produced.

This new codification of information is used to govern the next cycle of information transaction, which means that a new kind of translation regime has to be generated. So it can be seen that there is a continuing process in the codification of information used in order to generate a better way to exchange information among participants of the web of collaboration.

As previously mentioned, by using the IPMIS system the Director is in a better position to develop the codification of information for the new regime of the translation regime and better at monitoring and controlling the evolution of this translation regime. However, by using IPMIS, the process of information transaction of CRC WS can be controlled by BHP, given that through IPMIS, BHP can impose its codification in the process of information transaction. The main emphasis of CRC WS operation is based on the information flow in and out and processing within the Information Mixing Pot. The resulting type of information from this Information Mixing Pot is the only one which determines the direction of the process of information codification in the collaborative research partnership.

With the existence of IPMIS this process is effectively enhanced making BHP become *master* of the collaboration and leaving other participant as slaves. BHP is the master given its position as the initiator of collaboration, that is by delivering the particular type of information that triggers the collaboration. Moreover, BHP is also the creator of IPMIS, which is obviously responsible for developing most of the codification in the process of information transaction, given that IPMIS is the most important information transaction platform in this CRC. It is thus understandable that the innovation created from the

Information Mixing Pot will come from the information provided by BHP and formed under BHP's codification.

Moreover, the IPMIS can also be used to create a single codification system so that the translation process can be conducted in an easier way because in using IPMIS, all reports, and all kinds of information transaction must be worked out in a form that it is suitable to the IPMIS platform. Any attempt of information transaction in a non-IPMIS format cannot be processed. Therefore, there is an interesting relationship between an information system such as IPMIS and the process of the regime in translating the codification of information transaction, which will determine the relationship among participants. IPMIS can obviously be a main tool for the master to impose its codification on the slaves.

Thus relationships among participants may become dependent on a particular information system in that process. Before the application of the IPMIS system, the processes of monitoring and supervision of the project had been conducted by using fax and telephones. With the advent of the Internet the upgrading of the capability (in monitoring and supervision of the project) has been significantly increased. The availability of this Internet also enables the Director to support her/his job in dealing with more complicated developments of information codification and anticipation of problems of the translation regime from other research entities, especially from overseas.

The relationship between the Internet as an element to strengthen the process of conversion from one codification of information to another and thus its effect on the performance of the translation regime can be seen here. Without such an IPMIS system the network would operate slower and performance of the translation regime might become less effective. It must be noted here that the solution to problems (in this CRC) sometimes involves more contribution from the overseas participants giving the usage of the Internet a bigger role in the process of the codification.

Moreover, by using this IPMIS the codification process can be more centralized, so that the entire codification can be more easily converted into a single-CRC WS codification.

6.4. AN ASSESSMENT OF THE "NEWT" MODEL IN THE CRC WS

This section assesses the Newt model in the CRC WS. To what extent this model works will be discussed. In this CRC the 'master' is BHP. This organization has the largest information repository. For the Newt model, this organization rules the collaborative research partnership. BHP was the initiator of the collaboration. Working with CRC WS has enabled BHP to solve one of the most important problems in the field of pipelines, which is the time required for welding the pipelines, the so-called 'welding time'.

The WTIA and later APIA have interesting roles. These two industry consortiums both have large repositories of information and may rule the other smaller organizations within the web of collaboration. In fact it is somewhat different, because these two consortiums consist of many other smaller organizations and they are the major suppliers of the information to these two large industry consortiums. BHP as master dominates the collaborative research partnership by controlling the process of transaction of the main type of information. This kind of information is also the trigger from which other participants can gain benefit.

ANSTO for example can get benefit from this information: so that they can build better-sealed engineering construction for their important nuclear research facilities. Numerous members from WTIA, which consists mostly of welders and practicians of welding, can benefit from this activity is increasing their information capacity in solving problems in welding. The university and public sector research participants are clearly the 'slaves' given their limited potential for solving the master's problem; in this case BHP. These two types of participants (university and PSR) however may benefit by getting more types of information (and its codification) for their new research dimension (for the PSR) and for new modules of teaching materials (for the university).

The existence and application of the Internet for information transaction has been conducive to speeding up and easing this master and slave relationship. The CRC WS has used an Internet based information system, called IPMIS, which allows the participants of this collaboration to conduct the process of information transaction through the Internet. For example by allowing them to monitor an entire project from its inception to conclusion. This IPMIS was established by BHP, it was aimed to improve the process of information transaction in the CRC WS. For the Newt model, this information system can be a platform where the entire codification in the collaboration can be brought into one single codification, allowing BHP to "control" the process of information transaction.

The translation of the information codification of all the participants has enabled BHP to understand more about the information codification used by all participants and better utilize them to solve its problems in its function as master. BHP as master can thus better mobilize the entire participants of the collaboration to supply all required information for

BHP's benefit. The IPMIS system is helping BHP to do this. Thus the CRC WS as a translation regime has been performing as a facilitator for BHP as the master, and IPMIS has helped to achieve this objective.

When BHP's requirements became more complicated and at the same time CRC has performed as a good translation regime for BHP with respect to the codification of codes used by other participants, this allows BHP, as master to trigger the changing of the CRC, from CRC-MWJ to CRC-WS. For the Newt model, the evolution of CRC WS (previously it was designated as CRC MWJ) is also from the strong involvement of BHP based on the previous successful master to slave relationship in CRC MWJ. In this CRC there are two other participants which can be considered as "special". These are WTIA and APIA. The status of BHP as master allows the members of APIA and WTIA to get involved within the web of collaboration of CRC WS. With the role of CRC WS as a translation regime there will be a diffusion in the mastership role of BHP for all members of WTIA and APIA consortiums. As the Newt model suggests, there is master to slave relationship in the process of information transaction in this CRC. The master in CRC WS is BHP Pty. Ltd. Thus it is the type of information provided by BHP which controls the process of information mixing in the Information Mixing Pot. The codification of information must be referred to that information which is provided by BHP. BHP as master will be the most innovative and get the most benefit of this CRC program. Table 6.2 summarizes the assessment of Newt Model to the CRC WS.

Table 6.2 (I). The Newt model applied to CRC WS (continued on next page). Source: Author.

Theories from Newt model	The process of information transaction in the operation of CRC WS	Comments
The operation of a CRC is an arena of information transaction. It must be triggered by a particular type of information and the operation must be based on this particular type of information.	Yes	The need to deal with problems faced by BHP especially dealing with welding time in steel welding is the main issue, which triggers the collaboration. The other participants are contributing information to improve the value of this information.
Each participant is assumed to have its own information within its own codification, while the transaction process requires a transfer of information from one participant to others. In such case, there is a need for a translation media this is called translation regime.	Yes	The research providers provide particular information and maintain their codification of information transaction. Such as requiring a part of basic research activity prior jumping to applied activity. The industries put their representatives in each part of the projects. The Board of Directors provides a catalyst to convey all these differences.
The process of information transaction is thus dependent on the role of the translation regime. The translation regime is dependent on a particular participant.	Yes	CRC WS (under strong influence of BHP) acts as a translation regime with BHP as being the participant, which submits the main type of information. Many projects have been linked to BHP's style of codification.
The process of information transaction is codification of information from each participant to CRC codification and exchange this information to the other participant through information channel which is also under CRC codification. This process must happen reflexively.	Yes	The spider diagram has been used to show the role of CRC WS as a translation regime under the influence of BHP by using IPMIS
This has implication to the relationship among participants in the CRC. The participant which submits that particular type of information may have a special role. The relationship among participant is a master to slave relationship.	Yes	BHP is thus the master. All other participants are slaves.

The Newt model has explained the process of information transaction within this CRC. As the Newt model suggests the participants are coming from different working entities, and there is need to have a regime which will translate the codification used among participants. This regime is played by CRC MWJ under strong influence of the BHP, as master.

Table 6.2. (II) The Newt model applied to CRC WS. Source: Author.

Theories from Newt model	The process of information transaction in the operation of CRC WS	Comments
The information system may contribute to support the process of information transaction.	Yes	The BHP-created IPMIS provides the platform of single codified system of information transaction. This system has been successful in bringing all the codification used by participants into one uniformed codification.
The information system may support the master to "rule" the other participants (the slaves).	Yes	IPMIS is a highly codified method of information transaction. All type of information transacted must be set under its format. This simplifies the master in "mastering" the process of information transaction, both in terms of content and value of the information.

BHP becomes more innovative by using this kind of collaborative research partnership. The translation regime then evolves to CRC WS, due to nature of the translation regime itself.

It was the BHP as master, which stood behind this evolution, for this master rules the main information being transacted, which triggers the entire collaboration. In fact there are two other participants which have special roles, these are the WTIA and APIA, both possess quite significant information repository in dealing with problems faced by the master. The integrated information system has helped the master to exercise its role in the collaboration. This is a consequence of the Newt model which puts emphasis on the importance of the information system.

BHP has seen many benefits from establishing the CRC WS. Most of BHP's technical problem can be delivered to CRC WS, translated to the participants and benefit from participant's possible expertise to find the solution. The BHP is unlikely to cease the collaboration for many innovations can be created through this collaboration and given that the main type of information is provided by BHP, the type of innovation which will be created will be that which is beneficial for BHP.

6.5. CONCLUSIONS.

This chapter has presented the analysis of Newt model in the CRC WS. The analysis concludes that there is a particular type of information that has played important role in the process of information transaction, has triggered and determined operation of the entire collaboration, and has contributed to determining the positions of the participants within the web of collaboration. According to the Newt model this creates a master to slave relationship.

Furthermore, as Newt model has suggested, this chapter argues the master is the one which delivers that main type of information. It has been concluded that transaction of this particular type of information has affected the management of CRC collaboration by determining the process of de-codification and re-codification in the so-called Information Mixing Pot, which delivers a new type of information. This new type of information may change the entire network of collaboration. The existence of the Information Mixing Pot is caused by the need to develop a mechanism where the different codification (of information and its process of transaction) from many different participants can be processed.

The analysis has also commented an important role of the Director of CRC WS. This figure has to coordinate the process of transaction of information within Information Mixing Pot.

The Director has to manage the process of de-codification and re-codification of information and make sure that the information which has been codified fits with the main type of information submitted by the master. The ability of Director to manage this information codification process within the Information Mixing Pot may contribute to the success of collaboration. However, it must be stressed here, that such role must be exercised in a way that improves the type of information provided by the master. Working in this way, the Director's role may help in determining the trend and direction of evolution of the collaborative network. The Director is an important agent in the translation regime in enabling a reflexive and adaptable translation of the main type of information provided by the master with respect to all dynamics.

The analysis concludes that the Internet information system affects the process of information transaction in this CRC. The IPMIS, a BHP-created Internet information system, has been helpful in assisting the Director in performing the task as main agent of the translation regime. However this Internet information system contributes to the creation of master to slave relationship by determining the only possible information codification for the entire CRC WS collaboration.

The process of information transaction and the role of the information system in this CRC closely resemble the Newt model prediction. That is the existence of master to slave relationship, with a significant role for this information system in creating such relationship. Finally this chapter concludes that maintaining such relationship contributed to the operation of this CRC again as suggested by the Newt model.

<u>CHAPTER 7:</u> CASE STUDY 2: THE CRC FOR QUALITY WHEAT (CRC QW)

"The Co-operative Research Centre for Quality Wheat (CRC QW) was formally established in July 1995 by the initiative of 12 organizations representing the major public and private research providers to the wheat industry. There are four major manufacturers of wheat-based products (Arnotts Biscuits Ltd, Defiance Mills Ltd, George Weston Foods Ltd and Goodman Fielder Ltd), the Grains Research and Development Corporation, the Australian Wheat Board, New South Wales Agriculture, Agriculture Western Australia, the New Zealand Crop and Food Industry, plus one Public Sector Research Agency, the Commonwealth Science Industry and Research Organization (CSIRO) Plant Industry and one university, the University of Sydney". (CRC for Quality Wheat, Annual Report 1995/1996: p 1) A more detailed description of the participants in this CRC is given in figure 7.1 (see next page). The mission and objectives of this CRC are given in the following captions,

> "The CRC QW mission is to support the commercial development of the wheat growing and product industry- the grower to consumer perspective". (CRC for Quality Wheat, Annual Report 1995/1996: p 1)

> The CRC QW's objectives are": (a) to develop new wheats and new products (food ingredients, feed and alternative use) that provide consistency and meet the quality requirements of domestic and export markets; (b) to develop improved diagnostic techniques to accurately identify wheat and product quality consistency at different points in the value added chain (c) to develop wheat production, handling and processing technology to improve industry capacity to utilise wheat of varying characteristics, thus improving the product performance of these wheats (d) to improve product consistency and reduce processing costs through accelerated adoption of high technology manufacturing systems with built in objective quality management characteristics (e) to increase the supply of highly trained and skilled people in the industry and the organizations servicing it (f) to enhance the competitive ability of wheat industry research and technological services sectors to build (pre competitive) knowledge to service Australian and overseas firms". (CRC for Quality Wheat, Annual Report 1995/1996: p 1)

This chapter discusses the application of the Newt model in order to explain the process of information transaction in both the establishment and operation of CRC QW.

The organization of this chapter is as follows. Section 7.1 discusses the establishment of this CRC from an information perspective. Section 7.2 discusses the operation of this CRC from an information perspective, most importantly the investigation of the relationships among participants and the role of the information system in the operation of CRC. Section 7.3 discusses the application of the Newt model to explain the process of information transaction in this CRC. Section 7.4 discusses to what extent the Newt model works in this particular CRC and finally section 7.5 describes some important conclusions.

7.1. THE ESTABLISHMENT OF CRC QW FROM AN INFORMATION PERSPECTIVE.

This section describes the establishment of CRC QW from an information perspective. The main objective of this section is to discuss the type of information, which triggers the entire collaboration. In order to identify this critical type of information within this collaborative research partnership, the following approach is used: (1) from where the information is coming; (2) what type of information drives and gives birth to this co-operative research centre; (3) how it comes to be there and (4) how is it used. The structure of CRC QW collaboration is given in the following figure 7.1 (see next page).

The CRC QW collaboration will create a conducive situation for innovation, as a cluster of market leaders, growers and innovators grouped in the same research entity for a mutual benefit.

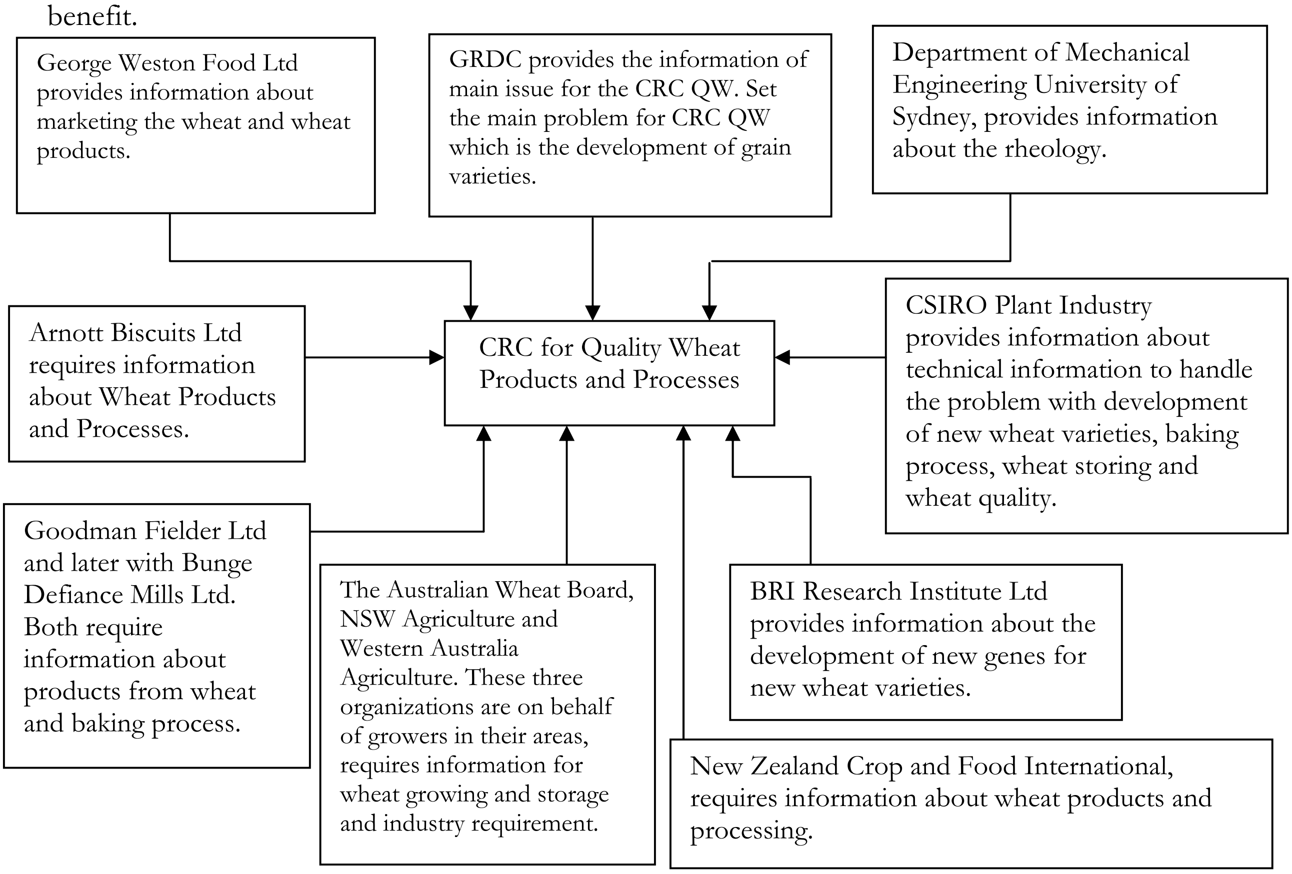

Figure 7.1. Participants in the CRC QW.
Source: Author, compiled from CRC QW Annual Reports, 1995/96 to 1998/99

The CRC QW enables participants to come up with winning innovation strategies for the transformational period of the next few years. The CRC QW helps participants to have a clear understanding of business progress and current advances in process redesign and simplification, supply chain synchronisation, integration of capital markets, application of technology to business management, and rapid adoption of network technology to supply the critical foundations for succeeding in the future. The CRC QW also helps its participants in better formulating their projects and making their projects fit the market, technology development and innovation and the company's objective. In fact, the particular role of

GRDC is very interesting in making the application of the CRC QW become successful, as the Executive Director of GRDC illustrates in the following quote:

> In the second round of the CRC application, there was an attempt to establish CRC QW, but it was not successful. So in the third round my organization took role as broker, to intermediate. It fell to me in the GRDC to encourage that activity. We took the view that in order to be successful it would be necessary to have very strong support from the industry[1].

There was thus a strong industry initiative in the establishment of the CRC QW. Meanwhile the strong support from PSR was also important in establishment of the CRC, as indicated by the Assistant Chief of the CSIRO Plant Industry:

> One of our senior research scientists, Dr. Rudi Appels, was involved in setting up this CRC. And the reason that he did this goes back five or six years from now. It was when they thought, that it would be a great advantage to bring together the work that was being done on wheat quality: that is flour, protein starches, and the type of properties of wheat, constituting of wheat research that was being done in CSIRO Plant Industry. In particular the GRDC and the BRI, the Bread Research Institute in Sydney, and Sydney University and the other partners, came in because they were interested in production of wheat of high quality. And there were also State Departments in NSW and in Western Australia and New Zealand Crop and Food. So, they were, sort of different type of entities and there were also industry components for example: Goodman Fielder, George Weston and at that stage it was Bunges. So it finished up with quite a large number of participants, probably more than you would want.[2]

"By end of the year 2000 or more than 5 years after its operation, this CRC QW has undergone some changes in its structure and management. In the first two years this CRC worked in three program structures, however over time it was felt that a more effective program could be achieved by the establishment of a five program structure whereby the education program, whilst coordinated by the Centre's Education and Training officer was absorbed within the relevant program". (CRC QW Annual Report 1997/1998:p 12). (see table 7.1) The establishment of CRC QW cannot be separated from the strong support and involvement of a large industry-research investor in grain, the GRDC. For GRDC a

[1] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

collaborative research mechanism, such as CRC QW is very conducive for increasing the information capacity of this large organization, specifically in regard to wheat-growth and the development of new varieties of wheat in Australia[3].

Table 7.1. The CRC QW programs.
Source: CRC QW Annual Reports from 1995/1996 to 1999/2000.

Year 1995 - 1996		**Year 1997 - 2000**	
Program 1	Integrating Products, Process and Wheat Quality	Program 1	New Wheat and Breeding Aids
Program 2	Controlling and Modifying Wheat Quality	Program 2	Growing and Storing Quality Wheat
Program 3	Education and Training	Program 3	Processing of Wheat and Wheat Products (Milling)
		Program 3	Processing of Wheat and Wheat Products (Baking)
		Program 4	Products from Wheat
		Program 5	Flour and Dough Components and their Interaction

This organization, GRDC, is a nation wide organization, which invests money for doing research in grain for national benefits, with the following functions: (a) investigating and evaluating requirements for R & D in the grains industry (b) coordinating or funding the carrying out of R & D activities (c) facilitating the dissemination, adoption and commercialization of the results of R & D[4]. Moreover, the GRDC sees the CRC QW as a positive way to spend their research funds on behalf of their growth, in particular, because when the idea was set up, there was no CRC dealing with grains development and the grains industry. The following quote from the Executive Director of GRDC illustrates this perspective:

> The GRDC represents the growth, the grain growths, but in putting together the CRC partnership, we were also involved in the downstream sector, and it was quite interesting, that we were able to get the major users of wheat, these were: Goodman Fielder, George Weston, Bunge Defiance Mills and Arnotts Biscuits. We were able to

[2] Interview with Dr. John Huppatz, Assistant Chief, CSIRO Plant Industry, February 7, 2000.
[3] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[4] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

> persuade them to be part of this CRC, because there would be mutual benefit. And, so the CRC was established with twelve members of which the GRDC is one. And we agreed, again, in order to emphasize the importance of CRC for the grain industry, we agreed that we would make an investment of one million dollars per year into this CRC. And that one million dollars, we said, would be unaffected. In other words, it would not be directed to any of our project, but CRC will determine the usage of that money. That is quite unusual, normally we make our investment only for our project, but in this case we believe, look, this CRC is an important activity, we believe that, so one million dollars per year is available[5].

The other reason for a big organization such as GRDC to take a role in the CRC QW program is to find a way to maximize the impact of their investment in research and development[6]. The GRDC had seen grains development as a good opportunity to open a new field of research and based on GRDC knowledge about possible business and market for grains, this organization became particularly interested in supporting the establishment of CRC QW[7].

The GRDC involvement was successful in two ways[8]: (a) helping the setting up of the proposal by giving more input so that the objectives could be converted to be more focused and executable objectives. Before the advice from GRDC, the CRC QW proposal was rejected because its objectives were considered as being too wide. The GRDC suggested to narrow down the objectives specifically to the development of wheat varieties and wheat-growth, as the Executive Director of GRDC points out in the following quote:

> The reason that the original bid for this CRC in the second round failed, was because they tried to do too many things. The reason that this was successful was, that we supported to focus very clearly on quality wheat products and processes[9].

[5] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[6] Ibid.
[7] Ibid.
[8] Ibid.
[9] Ibid.

(b). The GRDC as a big organization which invests money for research in grains and wheat already had some industries as members. Furthermore GRDC's function itself is strongly related to the need to increase its information capacity in dealing with problems in the wheat industry[10]. As noted, the GRDC management was successful in persuading the members of this group (especially industries) to contribute and participate in the program and to make narrower, more specific and more attractive objectives for the CRC QW programs. So, the role of the GRDC is particularly important in attracting more industry to join the co-operative program. The following quote is from a representative of an industry participant who was asked the reason for joining this CRC QW:

> The way it happened was, the GRDC, you know what I mean with GRDC, believed that the CRC was about grains, at that time just about wheat, and then was about grains, was a good idea. There was no CRC covering the grain industry at that time. What the GRDC did, was to approach appropriate industry partners and talk to all research people, at that time, and talk to the industry. They said to the industry, that, first of all, they thought that this was a good idea. And we said that we believed that it probably was. And the second thing, it was decided, that the CRC would be completely developed along the issues coming out from the industry rather than asking the academics to base it on the research program. So the original program was set by industry[11].

After the industry participants had been attracted to this program, it was the industry participants, which tendered the program to research providers (university and Public Sector Research)[12]. The previous quotes that indicate the role of the GRDC in the establishment of this CRC suggest the importance of a particular type of information in the establishment of this CRC. This is in particular the type of information, which is important for the increase in the level of knowledge capacity of the GRDC, especially in order to fulfil its main function as research investor. It is interesting that the research providers also joined this CRC QW in order to get access to a particular type of information. In this case the Department of

[10] Interview with Prof.John Lovett, Executive Director of GRDC, February 4, 2000.
[11] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

Mechatronics and Mechanical Engineering-University of Sydney (DMME-UoS) is taken as an example. The DMME-UoS has been doing research about manipulating dough by using a technology-knowledge called rheology[13], which has a direct application in the CRC QW. This university then joined the CRC QW and became the participant of this CRC QW. The following quote given by the Professor of this Department who is also a member of the CRC QW Board of Directors illustrates this point:

> So the industry partners from CRC QW asked the Sydney University if it would like to participate, and of course I was very interested. It was when I was Pro Vice Chancellor of University of Sydney. So, then the details began to be worked out at the centre, and of course we have a lot of work in plant breeding and agriculture which is one of the big focuses at the centre, but also there are a lot of industry partners which are interested in making bread and that involves manipulating the dough. And so, we said that we can work in that type of research with the bread dough, we can work on that, so we agreed to participate in this CRC [QW][14].

From DMME UoS's point of view, the main attractive feature for joining this CRC collaboration is given in the following quote[15]:

> This CRC QW give you access to more money. Some people say it actually works in the opposite direction, that we spend money for research, but my view has always been, that this collaboration with industry is an excellent thing so it is worth doing. What it really does mean, is that some people instead of doing completely free in the air research, work on the program of the CRC and this is an interesting thing[16].

Thus the two reasons for DMME-UoS to join this collaboration are: (1) this department wants to open a network of information, which permits more multilateral exchanges, so that it can give more access to more information for benefits of their research. In fact by joining CRC QW, DMME-UoS can get access to participate in more problems related to rheology and all those new problems can lead to a new research focus which, in turn can increase DMME-UoS research excellence especially in rheology, (2) by joining CRC QW program,

[12] Ibid.
[13] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. Univ.of Sydney, February 8, 2000.
[14] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. Univ.of Sydney, February 8, 2000.
[15] Ibid.
[16] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. Univ.of Sydney, February 8, 2000.

there will be more funding available for their research. From an information flow perspective it is clear that for DMME-UoS, there is a particular type of information and a particular channel of information which are being pursued.

The same reason applies to other industry participants. They are joining, the CRC QW to get input into technical information in order to solve their problems, as pointed out by the CEO of this CRC in the following quote:

> The main reason for people and organization joining this CRC QW program varies; some to get funding, some others to get a cross-side interaction. An industry is interested in specific technology that they see can help with their business and that is why they are here for[17].

The Public Sector Research Agency, in this case is the CSIRO Plant Industry is joining this CRC Program in order to pursue a particular type of research that can increase their research-capacity. The Assistant Chief of the CSIRO Plant Industry (who is also a member of the CRC QW Board of Directors) explains this in the following quote:

> The aims of the CRC program are quite clear, actually it is designed to benefit Australian industry so it is a way of introducing the research that has been done in the university and CSIRO, into the industry partners into their businesses. We would see CRC QW as a way of increasing our research effort in a particular research area in which we are interested[18].

An example of an industry participant of CRC QW collaboration is George Weston Food Ltd. This is a company involved in the manufacturing of flours, semolina and a wide variety of breads. This company joined this program mainly because of the following reasons[19]: (a) to get direct access to information related to the solution of their technical problems, specifically for baking (b) to increase the information capacity of their in-house research in the field of the baking process.

[17] Interview with Dr. William Rathmell, CEO CRC for Quality Wheat Ltd, November 29, 1999.
[18] Interview with Dr. John Huppatz, Assistant Chief, CSIRO Plant Industry, February 7, 2000.

The larger this information capacity, the more this company can deal with problems in this particular field. As noted, an industry participant is keen to participate in CRC QW provided that CRC QW's program would be completely developed along the issues coming from the industry[20]. By joining the CRC QW, the industry can get assistance in dealing with the processing of those types of information beneficial to their business and the industries can thus see this CRC as an opportunity to increase their information capacity for the benefits of their business[21]. In particular, by joining this program, this company (George Weston Food Ltd) can have more contact with more participants which enables this company to better specify information for solving the problems in making bread varieties and general bakery ingredients, easier access to market of these products and being able to get more inputs and new focus for their (in-house) research from the other participants[22].

In fact, before joining the CRC QW, George Weston Food Ltd had been communicating and having contract research with some research providers such as the CSIRO and UoS. However, the establishment of the CRC QW has helped simplify the procedure for doing such a collaborative research program[23]. Again, we can conclude that the above reasons reflect a strong indication of George Weston Food to increase the (in-house) information capacity for the benefits of their business, especially in solving of technical problems. For George Weston Food Ltd, the establishment of CRC QW also helps the access to not only technical information for the benefits of their business, but also to all related types of information associated with it such as bureaucracies and management[24]. Involvement in the

[19] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[20] Ibid.
[21] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[22] Ibid.
[23] Ibid.
[24] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

CRC program can help information processing so that all bureaucracy's problems can be reduced and enables this company to have easier and better contact with some experts from the university and public sector research agencies. The next section 7.2 discusses the process of information transaction among participants in this CRC QW.

7.2. THE OPERATION OF CRC QW FROM AN INFORMATION PERSPECTIVE

This section discusses the role of the critical type of information in the operation of CRC QW. The main objective of this section is to discuss the process of information transaction for all types of information introduced in section 7.1 in the operation of the CRC QW. This section also discusses the role of the information system in the process of information transaction in this CRC. Subsection 7.2.1 deals with the first issue and subsection 7.2.2 deals with the second issue.

7.2.1. THE PROCESS OF INFORMATION TRANSACTION

In fact, right from the start, the establishment of CRC QW, has been triggered by a particular type of information. The following quote from the Executive Director of GRDC illustrates this point:

> Why CRC has to be supported, why our people invest one million dollars to this organization? The reason is to produce a specific practice information about quality wheat product and process. That is why, this CRC exists. This exists to produce the highest quality technical information procedure[25].

[25] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

The operation of CRC QW is started by GRDC, given this organization is as the 'prime-mover' of the establishment of CRC QW[26]. The GRDC does not do research, but being an organization which has been investing money on research, GRDC is the only one, which may possess the largest information repository to the solutions of technical problems related to grains development faced by industry. The following quote from the Executive Director of GRDC illustrates this point:

> But, we do not do research, we invest in research, you see. But, let me out, the only thing that happens in the GRDC, which may be interesting to you. When we began we essentially reacted, in the sense that we advertised our proposals and the scientists told us what they would like to do and we made the decision whether we would support that or not[27].

The support given by GRDC to each of the proposals (submitted by members of the GRDC consortium) enables GRDC to understand the codification of information transaction used by those members (of GRDC-consortium). This may allow GRDC to collect more types of information including its codification from them. Having been doing this for years has made GRDC become the only participant which has the largest information capacity in research dealing with this technical problem in the field of grain. (GRDC Annual Report 1998/99, 1999) Thus as an organization, which has the largest information repository, it also has the capacity to trigger the flow of information. The Executive Director of GRDC points this out in the following quote:

> Then as we became more sophisticated internally, we then began to be more pro active. In other words, we advertised the thing that we thought was important and the scientist responded to, what we called, research prospectus. They responded to our prospectus, and now, we move to a stage that we call generative. This is because the GRDC is now so big and has so much information of its own, that we are able to define the project very precisely what we want to do[28].

[26] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[27] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[28] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

The above quote is an example of the way the GRDC can use its capacity of information and its codification (of transaction) to make a better identification of the research target. In this way GRDC is also in a position to make the recipient (of GRDC funding) following GRDC's set codification.

Besides the GRDC, at the same time, the other participants of CRC QW also submit the information to the "Information Mixing Pot". The Information Mixing Pot also helps to extract the most important type of information to be selected and removes all unnecessary information. The type of the information being submitted is in a very codified format given that it is dependent on different participants' skills and expertises plus some other contributions, and it has to be the type of information for solving the technical problems of the industry, as for example the following quotes from various participants of the CRC QW

> Well, the principal type of information that will come out of it, is the technical information and the technical information that would be of benefit to the Australian grain and wheat industry and I think in that sense the QW CRC has been quite successful[29].

> I think technical information for the development of grain varieties is the most important in this CRC[30].

The GRDC is also using the CRC QW as a method to support its effort in getting more types of information and including its codification. For the GRDC, there is a need to conduct this effort, in order to have a better impact on GRDC's information capacity. Because, this, in turn can increase GRDC expertise and excellence because there will be more research dimensions available to be funded and more information (from the research

[29] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[30] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

result) can be collected. The Executive Director of GRDC has pointed out this perspective in the following quote:

> Let me give an example. If you look at Argentina, which is also a major wheat exporter, it only exports one grade of wheat, Australia is exporting forty-two. Because we identify the market, many markets in SE Asia, in Europe and so on and we now deliver to meet the market needs, and this CRC helps us to do that[31].

Moreover, as an organization which, has been investing in research, GRDC is in such a position to have links of information with some industries, universities, and government agencies. (GRDC Annual Report 1998/99, 1999) In fact some industries have become members of recipients of GRDC sponsored research projects. The GRDC has also been encouraging and managing those industries to work in collaboration for the benefits of GRDC. Using these ways, enables GRDC to know exactly typical problems faced by industry involved in agriculture's business activities.

The university participant, the DMME-UoS contributes to the process of information transaction in this CRC by delivering its type of information in the so-called rheology[32] in a codified format[33]. The detailed content of information in rheology is the main type of information for DMME-UoS in dealing with other participants in CRC QW. The way, the transaction of information occurs, is conducted by using a very codified format of information transaction, as the representative of this university participant points out in the following quote:

> I have always thought that one can afford to do applied research. That is, put in that way, because that research usually creates new problems, at the very basic nature, that will be new problem that we have not thought before. And in order to solve

[31] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

[32] In simple terms, rheology is the study of the flow and deformation properties of a substance. Some substances like water have simple flow properties however wheat flour dough is non Newtonian and its properties are very unusual. While dough is not strictly a polymer, it does have the properties of polymer melt and much of the knowledge of polymer rheology can be used to describe its properties. Source : CRC QW Newsletter, Issue 5, page 3, June 2000. To measure this property, normally equipment called rheometer is used. The design and development of the rheometer has been activity of the Department of Mechanical and Mechatronics Engineering, University of Sydney.

[33] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. University of Sydney, February 8, 2000.

> those problems of basic research, we can use a little sum of the money that is coming to us. We can use it to say, well we cannot go on with this applied research, because we have to do this very basic thing first, so we can understand what we are doing[34].

From the above quote the DMME-UoS is defending its way of transacting the information in its codification as an education organization. The above statement reveals that DMME-UoS maintains its way of doing research by giving priority to basic and fundamental research.

The industry participants in the process of information transaction have also been using their own codification. For example, the George Weston Food Industry Pty. Ltd. as one of the CRC QW industry participants, puts its 'supervisor' to supervise all the research work contracted to the University of Sydney and the CSIRO Plant Industry as part of their mechanism in keeping the industry's codification of information transaction. The method of supervision is by using a formal meeting on a monthly basis and the results of the meeting are reported back to the Director of the George Weston Food Laboratories[35]. Moreover the industry wants to keep this method of information transaction in the course of CRC QW program[36].

For the industry-participants, the type of information, which is very important for them is that which solves technical problems[37]. Based on the type of information being exchanged, a particular codification of information transaction will be set up by the industry. The two following quotes from a representative of the CRC QW industry participant illustrate this point:

---

[34] Ibid.
[35] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[36] Ibid.
[37] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

> The way we work is: we put in-cash and in-kind contributions. How the cash is used that is up to the CRC. But we concentrate on our in-kind contribution. It is targeted into certain key areas where we have got specific interest and we actually work. In fact, in some of those, we lead the project[38].
>
> But, we are not actually contracting to the CRC and saying that, "I want you to do this particular job for us". No. We are indicating. We want things to get done in our way, we are not contracting them to do anything, no[39].

These statements reveal the very codified format of information exchange required by industry. The in-kind contribution is driven as such so that all types of information being exchanged (including the produced new type of information for the benefit of the industry) can be properly adjusted with the codified information exchange mechanism of the industry, so that it can readily be used by industry.

The above given three examples reveal that each participant contributes to a particular type of information, however in the process of transacting this type of information, each participant is doing this, in its own codification. During the course of the program, all the processes in the production of new information are conducted in a very codified format as well. For example the created new type of information must be accompanied by the progress report of all conducted projects. The following quote from a representative of an industry participant illustrates this point:

> Yes, I am getting reports from my people on a regular basis. They have to provide me with written reports, plus, in between, they have other meetings. When they talk about: what are they doing, what they have been doing, what problems they have got, what progress they are making, they must write down all the reports about those activities. Then follows through presentation, reporting and also just communication. Also I am often going to talk to them, we have one person who spends his entire time during CRC work and monitors the activities. So, anytime, I can talk to that person about how is this project going, how is that project going[40].

[38] Ibid.
[39] Ibid.
[40] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

The process of information transaction can be explained as follows. Internally, at the start-up of the program, all participants of the CRC QW collaboration program submit their types of information with their corresponding codifications about the research program to the CRC QW Board. A kind of process of mixing all this information with all the codification will be conducted. The result: a kind of new information with a kind of new agreed codification, which will be set, to start the program. The following quote from the Executive Director of GRDC, who is also a member of the Board of Directors illustrates this point:

> Well in a number of ways, but there must be, for example, as within the CRC program and within GRDC program there must be a mile-stone, there must be formal agreed key performance indicators. The indicators are monitored and if they, let's say, not met, then we can apply sanctions in terms of the budget and so forth. And indeed, I had just attended the CRC meeting yesterday and the managing Director told us that he had withheld payment from some of the CRC partners because they have not met their obligations[41].

In the practice the above process is conducted by members of the Board of Directors[42]. This process which is conducted by Board's members proceeds the mixing of information and this may generate a new type of information and its codification, which controls and drives the entire process of information transaction in the CRC QW. Externally, during that process, all the information submitted by participants is also compared and mixed with other types of information from outside (non CRC QW participants) including that from the government side (for relating this process with information related to e.g: funding, policies and regulations). Both processes are conducted in continuity during the execution of the program. The progress reports of the participants are used as another term of reference to mix up the type of information. The other type of information transaction in the operation of CRC QW is based on sending people around the participants of collaboration work and

[41] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[42] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

exploring the tacit knowledge embodied in these people for the benefits of the collaboration work[43]. The university participants of CRC QW are very keen to use this method of information exchange mechanism, such as sending and/or accepting new PhD, postgraduate students or adjunct professors who will introduce new problems and/or new solutions which could lead to a new innovation. However this kind of information exchange is still within the codification of the participant involved in the process. The following quote from a representative of a university participant illustrates this point:

> I think the main real transaction of information comes through people coming to work with us. For example we hired someone from the CSIRO to finish her PhD and she came to work here and she has been very good because she has had other skills that we did not have. We have this guy from New Zealand and also program leader in a project of this CRC who comes here as an adjunct professor sometimes and they bring their expertise here. We also have formal regular group meetings and seminars and so on. But I think the actual exchange of people is really what enables us to keep up with things[44].

The process of information transaction may create some problems given the nature of the information may change during the process of its transaction. The following quote from the Executive Director of GRDC illustrates this point:

> I think how the information is managed is very important in this CRC. For example: some of the technical information which is produced is really important along the innovation chain, and it may go from one of the scientists, let's say it may go from the molecular biologist of CRC but, it may go along the innovation chain of the plant breeders, okay. That's essentially the technical information from one group of scientists to another group of scientists. Once it goes from plant breeders then probably it is a different type of information, because maybe, it may need to become fame from plant breeders to farmers. So it is still part of the chain of innovation but the nature of the information changes. Okay, but it is still essentially technical information[45].

[43] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. University of Sydney, February 8, 2000.
[44] Ibid.
[45] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

The above quote reflects the need from the GRDC to manage the information transaction better. There is thus a need to really have a well-codified method of information transaction. In this case this organization (GRDC), being the largest and most important participant, is keen to create a well codified information exchange mechanism, by using the CRC QW as an instrument for managing a better information transaction to solve problems in the industries. However in terms of management of this very codified process of information transaction, other issues may occur, as indicated by two representatives from two CRC QW participants in the following quote:

> I think the areas there have been some areas of internal communications and lack of internal communications that was responsible for some functions have been frustrating. I think the policy surrounding the CRC is over bureaucratic. It took twelve months or a good nine months, once that actually a CRC could satisfy all the requirements to start its date[46].

> Over the life of the CRC which has been going now, around ten years, the system has became much more bureaucratic. And this is a barrier, I think, to an effective operation. The level of accountability is now extraordinary high. For example the idea of writing a complete and well-detailed research report every three months is quite ridiculous. That is what research in the CRC required to do now. In some ways it cannot be productive and you miss a lot of efficiency by imposing very strict bureaucracy on the system. It can still be accountable without that level of bureaucracy[47].

Another issue is that the industry participants in the CRC QW also consider the importance of the channel for exchanging the particular type of information especially that which deals with the description of a technical type of information from user to producer (of information) and vice versa[48]. This channel for exchanging the particular type of information has to be split into two categories: (1) one for competitive information and (2) the other for pre-competitive information. The reason is because one of the participants, the George

[46] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[47] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[48] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

Weston Food Industry Pty. Ltd., is doing similar business to another participant, the Goodman Fielder Pty. Ltd. These described problems again reflect the need for the CRC QW to conduct the information exchange including all the processes of doing that within the single CRC QW's style codification of information transaction.

Another issue in this process of information transaction is concerned with the number of participants. The more participants the CRC has, the more information flows and the more complicated the problems[49]. The other issue in this information transaction process is the confidentiality of the information. Some participants from the industry mostly worry about some types of information, which have business and economy values[50]. Some industry participants also have a problem with the internal information transaction mechanism. Thus, management of these problems is considered as difficult, unless there is a clear codification being imposed in that process.

Such codification of an information transaction can be addressed by using the following categories. Firstly, from the perspective of the industry's participants (mostly are research users) getting access to a particular type of technical information is important and their main interests in joining this CRC. Thus the channel of information must be codified in the following items: (a) the capabilities of a particular type of information to solve an industry problem, and (b) the benefits of a particular type of information to their business[51].

[49] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[50] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[51] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

Secondly, from the perspective of universities and research agencies (as research providers): getting access to a particular type of information from the industries and other participants is the main reason for joining this CRC QW. This will introduce them to new kinds of problems which in turn can help them in addressing some new research agendas which are beneficial for innovation. The codified channel for information exchange for the researchers from both universities and the public sector agencies is to the applied problems given by industries, which can lead to the creation of new basic research agendas[52].

In practice, the way peoples are addressing the above issues in the CRC QW (from an information perspective) is based on a formal process, mostly using regular meetings, regular monitoring, regular presentation and regular reporting. If there is a need to extend the meeting then extra (irregular) formal meetings will be arranged[53]. The meeting is based on two levels. These are: the Board level and the program/operational level[54]. In the CRC QW, a meeting, which is attended by all persons in charge of all programs is normally conducted once every month. Moreover the Director sometimes pays a visit to various locations to have direct contact with the participants of the program and to enforce the new created codification in the field. See the following quote from a member of the CRC QW Board of Directors:

> The Director has to attend the Board meeting, and he has to be credible and he has to convince the Board that he can deliver what the Board wants. He has to go to senior management meeting which consists of very highly regarded international scientists and he has to be credible there, and he has to tell them what the Board expects. And he has to completely understand when he has to deliver it, and then he has to go out to the various locations where the people are. So there are several levels of communications on which he has to operate, and of course when he is not

[52] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[53] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.
[54] Ibid.

> doing that personally, then he will do that using Lotus Note, or e-mail to maintain the CRC QW network goes[55].

Thus each participant in this CRC has its own information and its codification in transacting the information. The process of information transaction is thus a well-codified process, which is conducted by arranging formal meetings led by the CRC QW Director. The result of mixing this information is a new type of information and this will be offered to participants first (especially the industry) and then to the "outsiders", as seen in the following quote:

> I think this particular CRC is good example of how the model should work. So the 12 participants in CRC respect the interest of all. And for example if there is a piece of intellectual property to be taken to the market then it is offered internally to all the participants first. If none of the participants wish to commercialize then it is offered externally[56].

Therefore the main type of information and its codification specifically for the benefit of the industry's participants remain the main concern for the CRC QW as illustrated by a member of the CRC QW Board of Directors in the following quote:

> The main thing is the technical innovation for industry participants. There are also a number of secondary advantages but in principle industry gets an exposure to the value of research, to the impact of research, and they get an appreciation of how research can benefit them. So they become more research oriented[57].

The other fact is that each participant of this CRC QW keeps the personnel within their organization. This implies that the codification of information transaction used by each participant remains limited to their own. In the industry[58] the information transaction is by using a formal well-codified mode. In the first step, a researcher who invents something will discuss his/her invention with the fellow researcher and keep this discussion to the level of a

[55] Ibid.
[56] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

very well-codified format from their institution. Then the next step is to get management people and other senior people in the organization to discuss the matter and this is conducted in a formal way by using a codified method in the company.

The last step is to incorporate this program with other CRC QW participants, which means to incorporate their codification (of information transaction) with other CRC QW participants' codification of communication. In this process the role of the Director of CRC QW is particularly important. The way this is done in practice is through the Board of Directors, which develops the process of de-codification and re-codification of information exchange and the translation for each participant.

Thus from the previous discussions it can be understood that: (a) each participant is submitting information in its codified format (b) each participant tends to transact this information in a codified format as well. Therefore there is a need to have a kind of "translation" mechanism which has to translate the codification of each participant to others. This translation media is called a translation regime. The translation regime is realized in the practice by the Board of Directors who translates the used codification used by the researchers and all participants and coordinates the entire process of the information transaction. The following quote from a CEO of this CRC illustrates this point:

> The coordination is done by setting up the Board of Directors and appointed manager for each project or research program. The meeting is used as a tool for information transaction within the organization. The meeting with all persons in charge of the program is conducted once every month. The main topic is monitoring and reviewing of the progress of the research programs[59].

[57] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[58] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[59] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

The role of Director for the CRC QW is important. The Director of the CRC QW is the translation agent who must understand the codification of information of each participant. The Director has to determine the different levels of information transaction used by each participant and reflexively adapts the codification of information to other participants when communicating with the other participant. And the most important task is to create an environment within the CRC QW, so that such a kind of mechanism can be created. This allows for the creation of a translation regime, which operates reflexively. The following quote from a member of the CRC QW Board of Directors illustrates this point:

> The Director has to oversee the program within the CRC. The Director has to ensure that the information flow is effective and that it produces the result that we have set out. The Director of CRC is a rather interesting job, they do not manage, they work as facilitator, coordinator of the various research groups because the research groups do belong to their home organizations but they are allocated or part of them are allocated in kind for a specific project to the CRC. Now, the Director has direct control over those people so it is a very interesting situation. So the Director's job is not easy in the sense that he has to take into consideration the home organization of each of the researchers involved and at the same time he has to coordinate the work of the CRC into a coherent and productive entity[60].

As previously discussed participants operate in their own codification of information transaction. It is the task of the Director to deal with such complexity. A high level of credibility in the subject is a must for the Director. This is to enable the Director to understand the used codification of communication and develop the (new) codification for information transaction. As the following quote from a member of the CRC QW Board of Directors illustrates this point:

> I believe that in order to be successful the CRC Director must have a scientific credibility, otherwise he cannot deal with the people within the CRC. He may not necessarily be an internationally recognized scientist in his own right, but he must be credible. He must understand the disciplines. He must have the capability, and it is

[60] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.

> very important that he has management skills and he understands what drives people to work[61]

In the CRC QW all methods of scientific information transaction are also used. These are: internal seminars, e-mail, fax, exchanging drafts and labels and presentation in international conferences etc[62].

In fact CRC QW has also proposed to make the information transaction becomes better among research providers, and also between research providers and the industries. The research providers must be kept in a kind of package of information transaction codification and this package of information transaction codification must be aimed at supporting the industry. The different codification of information-transaction must be translated by the CRC QW and brought to the industry in the 'CRC QW' style format of information-transaction codification which is well understood by the industry. An example is the problem with competition for funding normally faced by a research provider. This has been anticipated by the establishment of the CRC QW to put them (these research providers) together and use them (these research providers) more efficiently for the industry, as the following quote from an industry participant illustrates:

> What I am saying is the research providers who are competing against each other for funds. That is what I mean by competition. And what I am saying is that since the advent of the CRC of QW, it has helped all research providers in some areas. So that they no longer have to compete for funds. So when we, from the industry, say: this is the project you should be working on, the research providers then, well I suppose, to some extent they are tendering but what tends to happen is, they are allocated those jobs according to their expertise. So they are ceasing to compete to some extent for the funds[63].

[61] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[62] Ibid.
[63] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.

The CRC QW has been successful in playing its part as a translation regime for the codification of information transaction. The following example from a participant (non-industry) of CRC QW illustrates this point:

> During this brain storming exercise which was six to seven years ago from now, it came out that there is a kind of practice, well a kind of reality, that where there are quite big problems and these problems are not started in the usual cereal science at all. It is the following: the breeders produce new varieties, it is grown, the produced variety has some quality levels, if you wish, which is a quite complex phenomena, because it depends on what you want to make from these varieties. Now, to what extent how much does it cost to dough and so on. It is very complex what is quality by the way. But in the big organization, it can be a big milling company as Weston gets an order, and these bakeries who wants to buy those flours they want such type of quality. With this CRC, now ninety nine per cent of the time, they can blend different varieties to produce that quality which the industry wants[64].

The above quotes stress the role of CRC as a translation media in conducting projects with several participants at once, something that was problematic before the existence of this CRC. All those mentioned brain-storming exercises were made possible by the CRC QW. The following quote given by an industry participant of the CRC QW also reveals the role of CRC QW as a translation regime.

> I think that what this CRC has achieved with this, in wheat, which has not been achievable before was to get the research, the cereal chemical, cereal industry research partners, to work together for a common goal and eliminate a certain amount of competition which used to exist between research operators. And it has been made easier, it has opened the gate for industry to engage in collaborative research. So rather than in the past, if we wanted to do something with, let us say, New South Wales Agriculture or the University of Sydney, we had to go along to the university. And we had to talk to the business liaison office etc, talk to the academics and it may have taken six months of drawing up of a project proposal and the rest of it. That could have been streamlined and a large number of projects have been identified which are essentially the industry partners can become main role of it [65].

In practice, the real operation of the CRC QW is manifested in CRC QW's programs. The setting of these programs at CRC QW has been arranged as such, to provide a better

[64] Interview with Dr.Ferenc Bekes, BRI Australia, Co.Ltd, October 5, 2000.

information transaction process and allowing all required codification to be exchanged between both vertical and horizontal chains of innovation, as illustrated in the following quote from a participant of this CRC:

> If you go through on program one, two, three, four and five, you can see a very logical sequence, even the numbering. Because program one is really the development of wheat with better quality, that means anything, which is related with wheat. Program two is the production of the economy, and effect on the environment and that type of purpose. And programs three and four are related to the processing and these are divided into milling, baking, and any other utilization of it. Program five, is dealing with different type of flour. We serve directly these five programs, providing basic research, cause-effect, and efficient time of planting. We develop method for the research for their breeding production and processing[66].

Program 1 main objective is aimed at the development of new wheat variety, which is very important for growers and farmers. The CRC QW program has helped the growers by applying the molecular biology techniques to develop new wheat variety. The following quote illustrates this point:

> To produce a new wheat variety is around eight years. What happens, first the breeders meet the process, and from the process the breeders need some good plans. Next year what he does is, if this plant survives at all, starts at looking for that money that you have on the head. Next year you can put that money in the plant. But you cannot have that money because you have to start to screen. You have to start to evaluate and this is in so much areas. Now, it is the reason to get enough information and enough mess from that process. How nice would it be, how cheaper would it be, if for one different type of quality measurement, let us say baking, could be done, not with 250 grams of grain, but only 2 grams of grain. In this case that screen could be done to various areas. The breeders could deal not with 2,000 but let say only 20 lances, which is a lot of money, a lot of energy to grow this sample, to get enough a kind of good, through its weight. Now this CRC develops this small scale testing means, that with a lot of very important engineering problems plus revolutionary chemistry, we develop plenty of different agriculture techniques that from 2 gram of flour, that means from 2 or 6 grams of grains, a breeder can learn what is the quality of that part. It comes up extremely good when molecular biology is the point, where through genetic engineering that gene transformation, it can produce a very new type of stuff[67].

---

[65] Interview with Dr.DAI Suter, Director of Weston Food Laboratories, a Division of George Weston Food Ltd, February 10, 2000.
[66] Interview with Dr.Ferenc Bekes, BRI Australia, Co.Ltd, October 5, 2000.
[67] Ibid.

Once this kind of variety has been developed a method to store the wheat with good variety must be developed. Program 2 is aimed at providing farmers and growers with tools and methods so that they can increase their opportunities for premium returns. The CRC QW by using intensive contact and interaction with farmers and growers (the horizontal chain of communication) has been successful in developing "The Growers Manual on Farm Management Practices to achieve Targets", and the so-called Wheat-Rite Test card[68] which was developed to determine the degree of rain damage on wheat. These two products are ready for use for the farmers and growers. These products have been developed because CRC QW has played its role as translation regime and successfully detects the communication codification used in the farm (between the horizontal chain of communication) and reflexively adapts with this codification and submits them to the vertical chain of communication, that is, to the scientists, and researchers from the industry and research providers. Working in this way also enables the development team, composed of participants with various functional specialisations, which, theoretically, makes them have access to more diverse types of information[69].

Program 3 is aimed at the development of the method for processing the wheat. This program is split into two parts, (1) milling, and (2) baking. The program is successful in making people aware of the results from CRC and distributes the results to the wheat breeders[70].

[68] Rain damage is a serious problem for farmers. As described under the question on the falling number test, grain can start to germinate in the head if it rains just before harvest. Although the grain may not be fully sprouted, after wetting it swells, and does not return to its previous size on drying out. This means the same weight of grain now fills a larger space, or, to put it another way, the same volume of grain weighs less. For example: Test or Hectolitre weight (the weight of 100 litres of grain) is used to assess the specific volume. Hectolitre weights of sound grain usually range between 76 and 84 kg per hectolitre, whereas weather damaged grain can fall as low as 60 kg per hectolitre. Normally, the grain, which has been damaged by rain must be stored separately and cannot be blended together with others. Failure to do so, may result in a disaster with order of billion of dollars worth. Source: Interview with Dr.Ferenc Bekes, Bread Research Institute Australia, Co.Ltd, October 5, 2000.

[69] Interview with Dr.Ferenc Bekes, Bread Research Institute Australia, Co.Ltd, October 5, 2000.

[70] Ibid.

Program 4 is titled the products from wheat. This program is concerned about the development of raw material specification and processing knowledge for major wheat base products[71]. Thus after the best variety of wheat has been selected, has been carefully and properly stored and has been processed, the next step is to determine what kind of products can be made from this first class wheat. Such a process of exchanging codes to deliver this kind of sequences can never happen without the role of the CRC QW. The research provider may have developed many techniques and methods but without the translation regime, which takes these codifications and reflexively adapts with other codifications from different participants, a kind of application of such techniques may never occur (see the following quote from a research partner of this CRC as an example):

> We think about the future, and we try to understand different biological, bio-chemical, biophysical questions. Which, if we are successful we can really, well not revolutionize, but big steps in the future. That means CRC is really a kind of research. Look, there were independent research units, research divisions and customers. We are now together. Traditionally we are not very close to the industry. That means that we do not have the actual thing. But I think that, as far as, how does it work, how direct, how frequent is this communication with the industry is concerned, it is in this CRC. Yes, now Quality Wheat CRC it really has produced an umbrella[72].

Finally, the focus of program 5 is on flour and dough components and their interaction underpins much of the research elsewhere in the CRC QW (previous programs)[73].The following examples illustrate that the ability of the translation regime in helping the process of information transaction in this CRC, may have some implications for the relationship among participants to this CRC.

[71] Ibid.
[72] Interview with Dr.Ferenc Bekes, BRI Australia, Co.Ltd, October 5, 2000.
[73] Ibid.

The first example is project number 4.1.1, titled "Defining Starch Quality for Enhanced Performance of Baked Products". (CRC for Quality Wheat Annual Report 1999/00, 2000:p 33) The starch forms the major component of wheat flour and makes an important contribution to bread characters. In this project the main objective is to seek and identify how changes in wheat starch characteristics affect baked quality. The project leader Dr. Hon Yun has linked this project to a GRDC project seeking to characterize the role of starch components for Asian noodles through this CRC QW, by putting the codification of information transaction of his team to GRDC's style codification with aid from the CRC QW boards[74] and this project has finally achieved a number of synergies, as the sample preparation methods are similar to that from the GRDC. However in the progress of the program this project has come under the strong influence of the GRDC's style of codification[75].

Another example is the project 2.1.2 where GRDC cleverly has taken the results of the entire program into a kind of compendium. (CRC for Quality Wheat Annual Report 1998/99, 1999:p 30) This compendium lists all the codified information about management practices for achieving premium targets, which is called Prime Hard quality (of grain). This compendium was then distributed to all members of the GRDC consortium and all growers within the CRC QW collaboration. The GRDC, from July to the end of 1999 also further introduced this codified information in dealing with management practices of grain treatment to all farmers nationwide[76]. The GRDC as investor of research projects in all of those fields is also in a position to control the flow of information, exchange of information

[74] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.
[75] Ibid.
[76] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.

and related communication exchanges. The breeders, such as Agriculture Western Australia, NSW Agriculture and the University of Sydney need the type of information of new wheat varieties with better quality, the way grain can be better stored and grown, and the required treatment for producing a better harvest[77]. The processors, the industry, such as Arnotts Biscuits Ltd., Goodman Fielders Ltd. and George Weston Food Ltd. need the type of information related to wheat processing especially milling and baking[78]. The other group (the marketeers) such as the Australia Wheat Board Ltd. requires the type of information about technical milling advices (AWB needs such type of information to impress its customers and this type of information for AWB represents the true value of the main outcomes of the work)[79]. Thus, this means that it is the GRDC, which develops the codification for exchanging information and for communication used among participants of the CRC QW. For the GRDC, the development of such codification to manage the control of flow of information and communication within the CRC QW can be viewed as a return of its investment on CRC QW[80].

Another interesting example is the project number 2.2.4 titled 'Maintaining Grain Quality during On-Farm Storage'. (CRC for Quality Wheat Annual Report 1998/99, 1999:p 64) This project develops a CD-ROM, which is full of instructions on effective practices for the delivery of quality assured products. These are information on all practical aspects on grain storage, from receival standards, storage structures, pest identification and control alternatives, to inspection and sampling, grain hygiene, farm safety, grain quality management on the farm, market requirements and storage economics. The CD-ROM also

---

77 Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

78 Ibid, for George Weston Food Ltd. also from interview with Dr.DAI Suter, Managing Director, Weston Food Laboratories, February 8, 2000.

79 Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

lists industry contacts for growers in case they need extra explanations. The previous subsection has described how a participant (the GRDC) can codify the process of information transaction in this CRC. The next subsection discusses the interesting role played by the Internet information system in such a process.

7.2.2. THE INFORMATION SYSTEM AND INFORMATION TRANSACTION

To enhance the process of an information transaction within this complex research collaboration, the CRC QW has been using Lotus-Notes, a kind of information system which is very appropriate for handling an efficient information exchange and reproducing information in a group located in different places[81]. This information system gives some benefits such as for data collection, creation of data banks and consequent large documentation of empirical evidences in the CRC QW projects and activities.

The Internet information system is also widely used in this CRC. The Internet provides web-sites about the usage of the CD-ROM produced by this CRC to all users, plus some useful addresses and all updated information for the users. This has allowed for collecting all growers into one single type of codification and this limits the growers in exchanging particular groups of information. Such well-codified type of information exchange has thus been enhanced by the Internet.

Moreover to extend the level of codification, the GRDC in March 1999 onwards conducted a series of courses on the usage of this CD-ROM to all GRDC members and all interested

[80] Ibid.

people using this CD-ROM. In early 2000, GRDC has already set-up a group of advisers nationwide to assist the users of this particular CD-ROM. (CRC for Quality Wheat Annual Report 1999/00, 2000:p 64) Thus there is a strong role for the GRDC to dominate nearly the entire process of information transaction by imposing the GRDC's style codification in information exchange. Therefore, the type of information being exchanged among growers will be completely dependent on this kind of codification. With GRDC as the main participant in this codification system of information exchange, it is clear that GRDC may dominate the entire collaboration and the Internet has helped in creating such a situation. Thus the role of Internet is interesting.

The introduction of the Internet has been to put the network of growers, advisers, handlers, processor, manufacturers and researchers into an effective information flow mechanism. (CRC QW Newsletter Issue 3, 1999:p 6) Basically, by doing it in this way, it means that this new kind of information technology is playing a role in creating the well-codified information exchange in this CRC. The Lotus Notes system is an example. This has been used by this CRC as a platform of (Internet based) information exchange. This Lotus-Notes system has allowed the process of exchanging information to be conducted in one single type of codification. In fact all participants have their own platform of information system which means that they already have got their own codification. However the CRC QW, in a somewhat forceful way, has imposed the CRC QW's version of the Lotus Notes system in the entire collaborative entity. See for example the following quote:

> The Internet is working absolutely well here and because of that you have to use it. We tried at the CRC, the Lotus Notes system networking exercise, I mean we do it, because all of our data is there, but it causes us a headache. Not because of the technology, not because of that particular set up or whatsoever, because don't forget

[81] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

> that this CRC is a network of twelve organizations. From these twelve organizations, around nine, have their own information system, and there are conflicts between the two networks. You could not avoid that. The board has made all us use their system. That sometimes creates a headache[82].

An interesting example is the fact that each participant has access to electronic mails and to web sites[83]. Researchers from different projects and different locations can easily monitor the progress of another projects by using regularly updated web sites, plus the existence of several mailing lists to discuss problems among themselves[84].

Another example of the role of the Internet in creating a special relationship among participants is the project-number 2.2.3 titled Wheat Quality information for producers, agronomists, and grain marketers. (CRC for Quality Wheat Annual Report 1998/99, 1999:p 63) This project has the objective to provide agronomists with information on wheat quality and receival testing and to provide them with CRC research outcomes so that they are better able to manage the crops, to produce them, in a cost effective manner, required by their end users. One of the methods for doing this is by setting up a web-site, which is always updated regularly and contains much information about the researches, publications and products of the CRC QW and especially the frequently asked questions with answers.

This Internet web-site also lists several useful sites and hot-link contacts to enable the participants to solve their problems. The development of this Internet web-site was a joint effort from GRDC, NSW Agriculture based in Orange and AWB with inputs from growers covering nearly all kinds of practical issues[85]. The usage of this web-site to distribute very

[82] Interview with Dr.Ferenc Bekes, BRI Australia, Co.Ltd, October 5, 2000.
[83] Ibid.
[84]Ibid.
[85] Interview with Dr. William Rathmell, CEO CRC QW November 29, 1999.

well codified information and the usage of the CD-ROM distributed by the CRC QW are both well accepted and used by a large proportion of growers[86].

Thus there are some methods of codification in the information transaction within the CRC QW's operation. These are: (a) encouraging people to work within the CRC QW's setting of codification of information exchange, such as by linking them together in the heavily codified Lotus Notes information system and through the Internet web-sites (b) introducing, and (c) transferring the research results to users, this includes through a fully codified education program within the CRC QW and (d) persuading them to apply these research results in the fields and this is strongly supported by the Internet information system.

Thus in summarizing, by making the information related activity in a well codified format the CRC QW does really support the creation of an easier process of information transaction in the network with the industries and other research providers. Using this CRC QW arrangement enables for example: the university to specify the relationship between the producer and user domains of (basic and applied) research, which in turn increases its information capacity for innovation. The main objective of the CRC which is to maximize the innovation capacity of the participants, mainly from the industry, has been achieved. The university, industry, public sector research agencies and investment organizations confess that the CRC QW has increased their innovation capacity. The following quotes illustrate this point:

> Well, the University of Sydney is pretty innovative. I think we have not became dramatically different, we just turn our attention to some other project. But, it has

[86] Ibid.

> been very helpful having this CRC QW. The CRC QW could help us start a new project, understanding industries better, so in that sense it is more innovative[87].
>
> I think, the advantages of the CRC program is and you can use CRC QW as an example, that is, it brings people from different institutions from different disciplines to a common, well understood focus and so there is a much greater cross fertilization of ideas so in a sense that greatly helps the innovative process[88]
> So we do not carry out our own research. But, if you were asking, does our investment in this CRC QW enhancing the growth of innovation in that part of the industry, then the answer is: yes[89].

The process of information transaction in the operation of the CRC QW is mainly under a single codified method of information transaction set up by the CRC QW under strong influence from GRDC. The success of the CRC QW's operation is dependent on the success of the process of information transaction, see for example the following quote:

> An important factor that determines the success of this CRC is this types of role. The role of the CRC in transferring its technical information to the people who then use it. Be they in the farming community, be they in the wheat area, be they in industry, be they milling, baking and storing and others[90].

The successful operation of the CRC QW has delivered the following benefits:[91](1) For the participants from public research agencies such as CSIRO Plant Industry, in general bringing people from different institutions, different backgrounds and different disciplines, it has been beneficial for increasing the innovation capacity of the organization; (2) for the participants from university, it helps with the creation and introduction of a new focus on research, which is considered as very beneficial for becoming more innovative. The CRC QW has helped the university to start with a new focus in their research. (3) For the participants from industry, it creates more new inputs about how research works can be beneficial for business. The CRC QW has been successful in making the Australian

---

[87] Interview with Prof. Roger Tanner, PN Russell Professor of Dept. of Mechanical Eng. University of Sydney, February 8, 2000.
[88] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.
[89] Interview with Prof. John Lovett, Executive Director of GRDC, February 4, 2000.
[90] Interview with Dr. John Huppatz, Assistant Chief CSIRO Plant Industry, February 7, 2000.

industries become more research oriented and has increased the research capacity of these industries. Previously the Australian industry was particularly bad at looking for technological innovation and in some cases some industries have preferred to do their research with their partners from overseas. The CRC QW has been successful in changing these environments and making Australian industry more aware how the research works. The CRC QW has also simplified industry access to research providers (such as universities and the CSIRO). Another benefit for the industry is that the CRC QW has been helping the industry by setting an agenda for a research program for the industry where the industry can have main role on it. Furthermore industry participants are also interested to join this CRC because CRC QW can provide new kind of common codification which may help in reducing the level of competition in business activities, especially competition among the research providers for funds from the industries.

(4) For the (research) investment organization (GRDC) it has been beneficial in opening the gate for more research programs and giving more inputs about markets and more possible investments to increase their growths. For the GRDC, which truly invests money in information, this means an improvement, for the available information would be available in a better codified format, so that it would be easier for the GRDC to 'select' the type of information, which can be further developed. This makes it easier for the GRDC to define the profit and impact for their dollars. The next section 7.3 discusses in detail the analysis for both the establishment and operation of this CRC by applying the Newt model developed in chapter 5.

[91] Interviews with: Dr John Huppatz, Assistant Chief, CSIRO Plant Industry; Prof. John Lovett, Executive Director GRDC; Prof. Roger

7.3. THE "NEWT" MODEL IN ACTION: CASE STUDY 2, THE CRC QW

This section analyzes the application of the Newt model to explain the operation of information transaction in the CRC QW. This model will be used to analyze the establishment and operation of information transaction in the CRC QW. The Newt model considers the CRC QW collaboration as an arena of information transaction among participants. This process must be started by a particular type of information, which is submitted by a particular participant and the entire process of information transaction is conducted within a particular codification (in the method of information transaction). Under such circumstances, a kind of relationship exists between participants in the collaboration and this relationship as the Newt model suggests is based on a master to slave relationship. This relationship may contribute to the success or failure of the CRC collaboration. In the previous section it has been described that the GRDC started the process of information transaction. The main issue which triggered the entire collaboration was the need to develop a new wheat variety. This issue attracted many participants and has started the collaboration. The establishment of this CRC from the Newt model perspective will be explained by using the analytical figure 7.2 below.

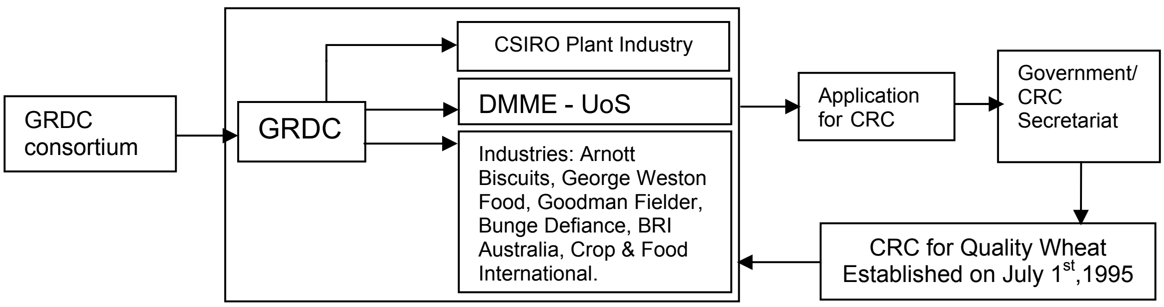

Figure 7.2. The establishment of the CRC for Quality Wheat from a Newt model perspective. Source: Author.

Tanner, PN Russell Professor Univ. of Sydney; and Dr. William Rathmell CEO CRC QW.

The GRDC as the prime mover of information activity, which gives birth to this CRC, is at the centre of figure 7.2. The information provided by the GRDC has some contributions from the GRDC consortium, which has many members from the grain and wheat industries.

This type of information from the GRDC is basically in its codified format, however given this organization has been dealing in this field for a long time and with a large number of members from industry dealing with a similar field, this has enabled the GRDC to "set" this information so that it is appropriate and can fit with the codification of the research providers (CSIRO and DMME UoS). The same applies to the industry participants, as for them it is not difficult to fit the information submitted by the GRDC to their "own" codification given the GRDC has had industry as its members. This combined information from all participants is submitted to the application proposal for this CRC. In fact the other participants may submit other types of information, but all their submitted information has a "content" of information submitted by the GRDC. The codification of this information enables the possibility for other participants to "understand" the information provided by the GRDC. The application proposal was submitted to the Government c.q secretariat of CRC and the CRC QW was formally established on July 1, 1995.

The information is then fed back to the entire collaboration and it will be used to drive and influence the process of information transaction in the operation of the CRC QW. All the information which will be produced, mixed, and created in the collaboration will have to refer to this particular type of information. Thus, this collaboration is triggered by the need to develop a particular type of information especially from the GRDC. More specifically, the technical type of information dealing with the development of a new grain variety, is the main type of information, which drives the participants to join the collaborative research entity of the CRC QW. The GRDC, thus provides the main type of information, which then triggers the entire collaboration. It is not surprising that a huge organization such as the GRDC has promoted this kind of collaborative research partnership. The GRDC has the largest information capacity especially that which deals with grain research and development, for its main function and role is as research investor in that field. The need to increase its information capacity has motivated the GRDC to become the prime mover for this collaborative research partnership. The GRDC can provide the information which may trigger the collaboration given this organization has got strong support from the GRDC consortium (see figure 7.2). The consortium can help identify the type of information which is critical and interesting to be developed in the collaboration.

Moreover, the GRDC is in a position to understand the codification used in all activities in this matter (grain research), given its position as the financier of so many previous projects related to this matter and having quite a large consortium dealing with this matter. As has been described in section 7.1, industry participants insist that the collaboration should be based on issues drawn from industry. This means that industries want this collaboration to be conducted in their own codification, given that the GRDC itself has already achieved a "collection of codification" from members of the GRDC consortium, many of which are industries. It is easy for the GRDC to interact with the industries and provide the research issues, and persuade the industries to accept them and to join the collaboration. Thus mastering the information in terms of its capacity to deal with a particular problem (including its codification) is the GRDC's main contribution in triggering the collaboration. The previous section 7.1 explains that after the start up of the collaboration each participant will transact information under their own codification. Thus the process of information transaction is within a strongly codified format. The Newt model suggests an analytical figure 7.3 to explain this (codified) process of information transaction as follows:

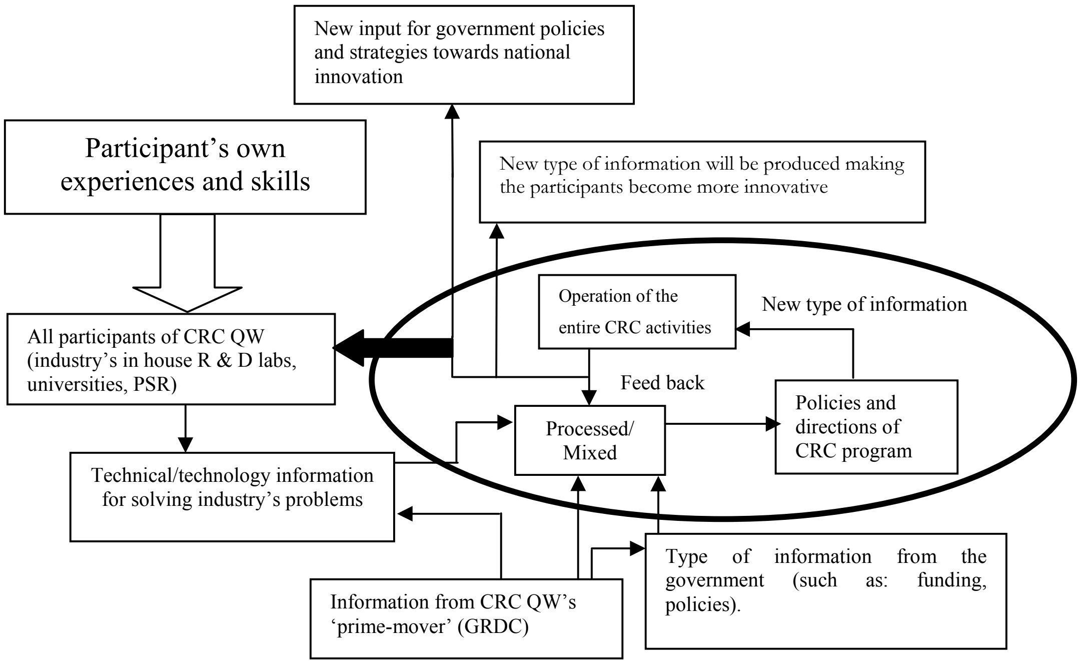

Figure 7.3. The CRC QW operation from an information flow perspective. Source: Author

The previously so-called the 'Information Mixing Pot' (section 5.4), is the box "Processed/Mixed" within the ellipse. The mixture of information is mixed up with other information from the GRDC as the prime-mover organization within the web, and information from the government (such as about funding and other policies). The result of this mixture is a new type of information and it is used to determine the CRC QW policies and directions. These policies and directions drive and manage the entire CRC QW's activities. Furthermore this type of information is also fed back to: (1) the 'Information Mixing Pot' where it is used as a reference for the new process, and to (2) all participants of the CRC QW. This cycle of process is continued during the course of the CRC QW operation. This kind of mode of operation creates a situation where information can be transferred only to a destination where such a situation has been created which needs that information to be there. This means that each participant can receive the information in the form of ready-made information to solve problems. In this the information from one part can readily be made available to other parts in the web of collaboration, a situation which, as the Newt model suggests, is highly conducive for creating innovation.

The above process is conducted within the Information Mixing Pot in two phases. The first phase is the de-codification of information submitted by various participants and the second phase is the re-codification to the CRC QW's style of codification (which is strongly under influence of GRDC's format of codification). After the entire process has finished, another codification is required to codify the information back to the participant's own codification. This is required because all the participants want to have the information in their own codification. These processes (which are located within the boxes in the ellipse in figure 7.3) are going on continually. From the figure, it can be seen that the information provided by the GRDC is the main driver for the entire collaborative network. This information is submitted to the box “technical and technology information for solving industry’s problems” which influences what type of information will be submitted by other participants. The same applies to the box “type of information from the government” which is influenced by the type of information provided by the GRDC. In the Information Mixing Pot, this information is mixed and is used to ‘control’ the collaboration. Thus it can be concluded that the GRDC, by determining the type of information submitted to the collaborative network, is in a position to influence the other participants in terms of the format of codification of information to be transacted and the process of information transaction. The GRDC, from this perspective, plays role as the ‘master’.

In practice, the operation of the Information Mixing Pot is conducted through Board meetings. It is in these meetings that the de-codification and re-codification of information takes place. Lotus Notes also helps the CRC QW in the process of de-codification and re-codification of information more systematically, because Lotus Notes records the entire information transaction during the meeting in a particular code and specific classification. The Newt model suggests that the type of information being transacted determines the method of codified process in transferring that type of information. While each participant has contributed different types of information, the process of transaction of this information must be conducted in a single codification. Thus, there is a need to have a translation regime, which allows the process of de-codification and re-codification of the type of information submitted by each participant. The Newt model suggests that in such a process of translation there will be a special role played by a particular participant. This interesting relationship among participants is a direct implication of the process of information transaction from the Newt model. Moreover the role of the Internet information system is quite important in the process of translating the codification from/of each participant. The following figure 7.4 pictures the position of the CRC QW as the translation regime in the web of collaboration among participants from industries, universities and PSR.

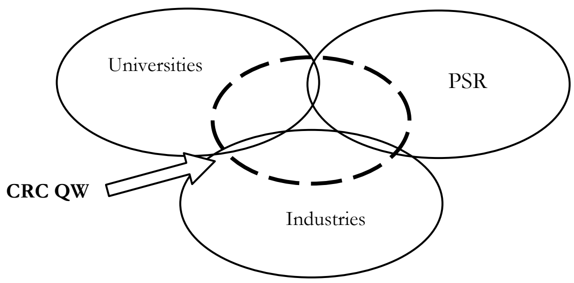

Figure 7.4. The position of the CRC QW as a translation regime among participants of a collaborative research partnership. Each ellipse represents codification used in communication within each participant. Source: Author.

The role of the GRDC in this translation regime is to shape the CRC's style codification for the entire process of information transaction.

As noted, the main type of information which triggered the collaboration at the CRC QW was introduced by the GRDC. It was because of this type of information from the GRDC that government gave approval and gave birth to the CRC QW. In the development of the CRC QW, the setting up of the programs were all based on this type of information provided by the GRDC. There is thus a strong relationship between the type of information and the capability to control the translation regime. With the highest level of information capacity especially in this strategic type of information, a participant such as the GRDC is in position to exercise the full role as master of the translation regime. This is because of its capability to translate nearly all codifications of information transaction, which means also the communication codification of every participant (an ellipse in figure 7.4). It reflexively adapts to the other participants (ellipse with dashed circle in figure 7.4 can move to any of the ellips that represents each of group of participant, i.e. industry, Public Sector Research agencies and universities) to solve problems and for other purposes including innovation. To explain this in more detail, the spider-diagram, figure 7.5 is used again to visualize the role of the CRC QW as a translation regime for the communication layers of growers and farmers to the industry, all using different codifications of communications. That is, the public sector research agencies use codification as public sector research agencies, universities with university codification etc. The following project from the CRC QW gives[92] an example of how this spider diagram works. Before the existence of the CRC QW there were problems from the translation of communication codification for the growers and farmers to the

[92] Interview with Dr. Ferenc Bekes, BRI Australia Co.Ltd, October 5, 2000.

industry (the so-called vertical chain of the communication process) and vice versa. The growers and farmers produce grain varieties.

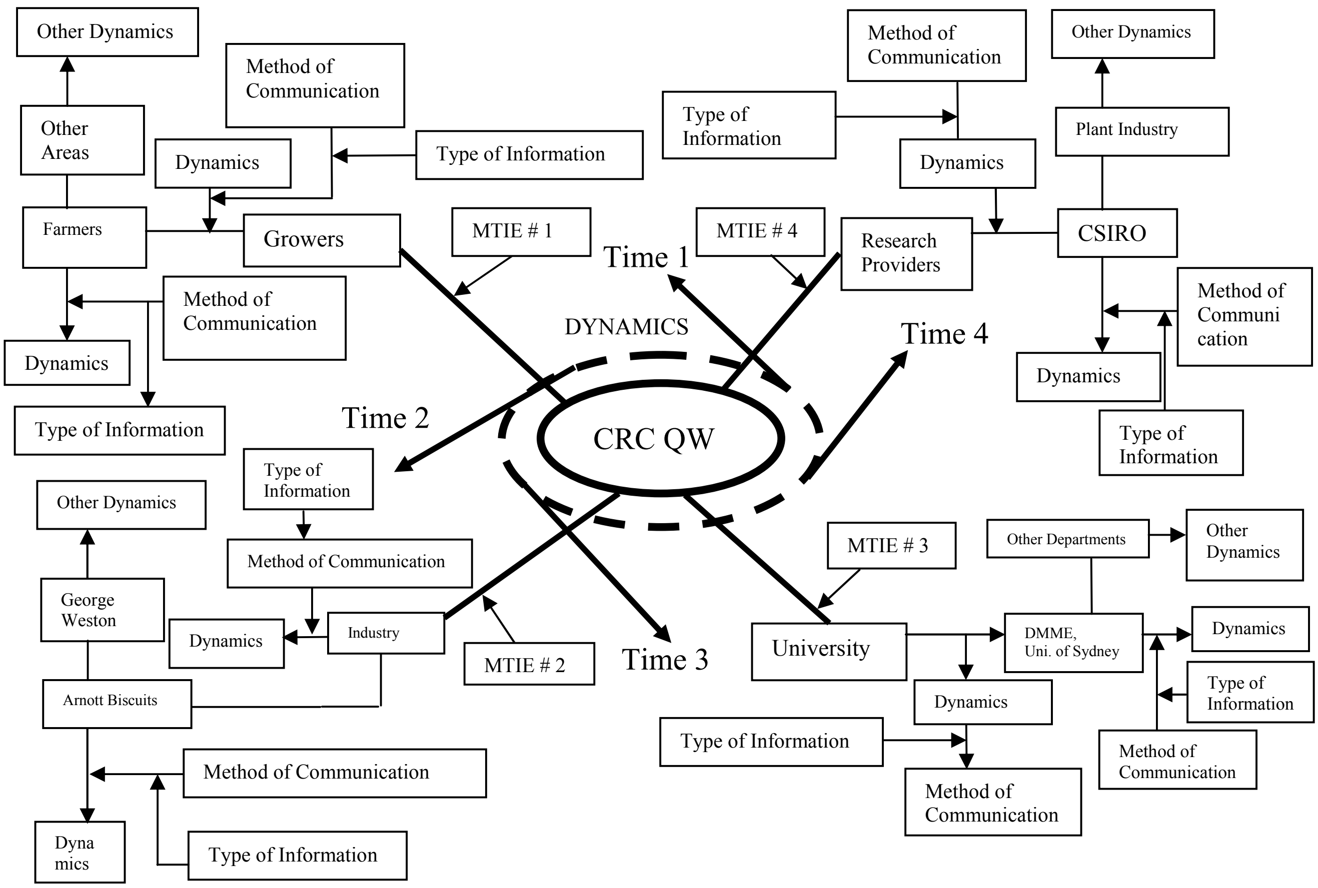

Figure 7.5. The 'spider' diagram to explain the role of the CRC QW as a translation regime for growers, farmers, industry and research providers. Source: Author.

These grains are grown to very different levels of quality. To determine what can be made from each grain variety requires a very complex phenomenon and involves various codifications of communication among growers and farmers (horizontal chain of communication).

One of the most important types of information which is being discussed in this codified communication is the information about the extent of how much it costs to make dough.

The industry requires dough and flour of a good quality. Blending these dough to produce what the industry wants has been the activities of these bakeries. The most important aspect is that in this blending exercise the bakeries use a very well codified communication system which can only be understood by bakeries. On the other hand the industry has its own codification, that is: they have a formula for blending the dough with different quality parameters.

The project set up by the CRC QW has developed a new codification of communication for the entire collaboration. This new CRC codification is pictured as an ellipse with a dashed line in the spider diagram figure 7.5. At Time 1, this ellipse will move to the web of growers and farmers (at the top left corner) and the main task is to understand the used codification among them in transferring the MTIE # 1. The web within them actually has many dynamics, given that within them there are other growers and farmers separated in many different areas with different climates and obviously with different problems in regard to the MTIE # 1. This MTIE #1 is the development of new grain varieties (a type of information which was firstly introduced by GRDC).

At Time 2, the ellipse moves to the web of industry (at the bottom left corner) and doing the same thing, this time translating the codification used by growers and farmers who are communicating with the MTIE # 2. The MTIE # 2 consists of the needs and requirements from the industry in regard to the dough developed from the new grain varieties.

The same thing is done at Time 3. This time, the ellipse will move to the web of the university, in this case it is the Department for Mechatronics and Mechanical Engineering

University of Sydney (DMME UoS). In fact the DMME UoS may have a collaboration with other departments and other faculties, and thus within this web there will be more dynamics, therefore the exchange of information will be done through a different communication. In this web the MTIE # 3 is the technology of measuring the important parameters of the dough. The DMME UoS has developed an instrument called the rheometer, which can perform this task.

Finally at Time 4, the ellipse will move to the web of research providers, the CSIRO Division for Plant Industry. The MTIE # 4 consists of all required analyse of molecular biology and chemical analysis of dough. Again within this web there are several different codifications from the research-provider's web (at the top right corner). CSIRO Plant Industry may involve people from different departments within the CSIRO. Thus the research provider's web has different communication codifications and these will create different dynamics. The dashed ellipse thus brings the MTIE #1 with its entire dynamics (the different layers of codification used in the web of farmers and growers) to the web of industry, to the university and to the CSIRO.

These activities of CRC QW have enabled direct involvement in the course of the project between people from industry and non-industry despite their different codification in communication. This kind of translation regime has created a direct interest from the industry and because of the experiments in industry, all participants learn a lot on the level of business side. A kind of reflexive translation regime operates and is able to select the best 'genotype' in each of the participants involved in the collaboration program.

The above project has been successful in developing a mathematical model which can describe the non-linear behaviour of the dough. This has been developed through strong interaction between CSIRO Plant Industry and DMME UoS[93]. Samples are taken, the chemical composition of the component measured and the quality of the blend can be predicted. The above example shows that the CRC QW has successfully translated the communication codification from each component of the vertical chain in the process of communication.

The CRC QW decided to expand the program after seeing that the type of information required by the participants had been better identified. This was caused by its better understanding (codification) of the problems encountered with wheat in Australia and the need to codify more of the problems with wheat in Australia in order to seek solutions (better codification) for the future. For the GRDC as the master, this has also been an effort to better control the slaves in the collaboration and retain its position in the future.

The information processing (the process of de-codification and re-codification of information) is able to solve specific industry problems which are related to technical matter. During this process some 'residues' may be created. These residues are basically another type of information which can be used by universities to create a new focus within their study program, a new method of teaching, and other improvements including making it easier for their graduates to be taken by industries. In CSIRO Plant Industry, this is mainly the type of information concerned with the cash contribution from industry. The information processing mainly deals with the solving of industry's technical problems and it can also help

[93] Interview with Dr.Ferenc Bekes, BRI Australia, Co.Ltd, October 5, 2000

to increase the CSIRO Plant Industry's innovation capacity, the generation of a new focus in research and the opening of a new dimension in technological innovation.

The GRDC also disseminates the new type of information created to GRDC's members, whether they are participants of CRC QW or not. For the government this new type of information created can be used as an input to draft new government policies and strategies towards national innovation in grains and perhaps other agriculture fields. Government policies are directed to improving access to external sources of information that organizations deem important for innovation and must always aim to benefit all firms in an industry. This may for example, take the form of dissemination and demonstrator programs displaying the best practices in order to explain to laggards what adopters are doing in collaboration initiatives to share information. The new information produced from the mixing of all information in the CRC QW program helps government in all these efforts given that government is able to understand the codification used by each participant involved in this field (grain and wheat industry).

It is predicted that in the future the CRC QW will evolve, given the number and types of information being exchanged and the increasing complexity of the problems encountered by participants and the possible threats from other entities (such as industry, which has to compete with other industries and overseas competitors). This may force the CRC QW to increase the number of codifications in the communication mechanism and this will change the dynamics and the character of the translation regime. The goal is to be able to select the best "genotype" among available layers of communication codification with its corresponding type of information, and reflexively adapt to the best fit "genotype" of the codification of communication. This will provoke a change in the entire project and activity, which will be followed by the changing of the entire collaboration. It is the translation regime which will perform this task and carry out the evolution of the CRC QW. Thus the dynamics of the collaborative organization may be directly related to the dynamics of the translation regime.

7.4. AN ASSESSMENT OF THE "NEWT" MODEL IN THE CRC QW

This section discusses an assessment of the Newt model in the CRC QW and in particular to what extent this model works for this particular CRC case study. As has been raised in section 7.3 the GRDC played a special role in this CRC because it was the information provided by GRDC that triggered the collaboration. For the Newt model the GRDC, thus functions as the master. As noted, the main issue in this CRC was to mobilize the participants in a well-codified research in order to create a new wheat variety. The codification is required so that it will be easier for the GRDC to control the information activities, such as the flow of information, the development of information, the creation of new types of information and making sure that all this information is improving the type of information provided by the GRDC. The other participants are the slaves in this CRC. The type of information submitted by the GRDC for developing a new wheat variety has spawned to many other types of information, and from this type of information the entire collaborative research program of the CRC has been derived. The process of all these information activities is mostly in a well-codified format. The first is the derivation of a new wheat variety followed by how to store it (for example including the development of all associated accessories such as the so-called Wheat Test kit to test the damage level of wheat).

Furthermore the research about baking follows as logical sequence. In this part a new kind of method developed by DMME-UoS takes place, which is rheology, which forms the basic knowledge in order to develop the so-called rheometer. The UoS had never conducted this kind of research (rheometer) for the application of rheology in the baking process. It was actually aimed for something else, but by joining the CRC QW this kind of device found application for something else, and this triggered more new theories for the UoS to increase their knowledge capacity in the field of rheology. This is the case where the CRC QW has been able to function as the translation regime, which reflexively translates the different dynamics from the participants. These dynamics are caused by the different method in the codification of information transaction, and the difference in the information transaction is caused by the type of information being exchanged. The collaboration program finally includes the training and education programs for the growers. In fact, an army of growers is the user of most of the CRC QW research results. This group forms the bulk of the users and most if not all of them are previous recipients of GRDC investment.

In this way the GRDC has been able to exercise its function as the master of the CRC QW because the development of the entire research must be based on the need of the research results from the growers. Meanwhile, the producers using the growers' deliverables, are the food industries such as George Weston and Goodman Fielder. Thus given that these growers are under the control of the GRDC in terms of information capacity then the GRDC is in a position to rule the industry through this CRC. Moreover, the mixing of information definitely produces innovation, making all participants more innovative under the strong influence of the GRDC as the master of the collaboration. The GRDC is able to bring the entire CRC into one single codified information entity, which includes the codification of the type of information being exchanged and the information transaction. This ensures that the type of information being developed in the innovation process is the derivative of information submitted by the GRDC. The dynamics which occur from the process of de-codification and re-codification can be determined by the GRDC given that the codification of information transaction at all layers of communication have been set up by the GRDC. The information system has been extensively supportive for enhancing the role of the GRDC in imposing its mastership at the CRC QW. The usage of an information system such as Lotus Notes which has been created with the strong support of the GRDC and the usage of the Internet application such as web-sites and e-mail as methods of information activities (web sites also have mailing list where people discuss with each other how to deal with particular problems) enable the GRDC to make the process of de-codification and re-codification easier and faster. This situation has promoted the application of codification from the GRDC, making everything more codified, and more easily codified, and thus easier to be 'controlled'. The CRC QW has thus played its role as a translation regime given that the collaborative research partnership performs well because the process of information transaction was successful. The translation of codification from different participants of the collaboration has been facilitated by the CRC QW as a translation regime (with the Director as the translation agent). Table 7.2 (page 233) lists the relevance of the Newt model in explaining the process of information transaction at this CRC.

The CRC QW has performed its function as a translation regime properly. The GRDC as the master, has seen many benefits from establishing the CRC QW. Most of the GRDC's technical problems can be delivered to CRC QW, translated to the participants and benefit from access from the participant's expertise to find the solution.

Table 7.2. The Newt model applied to CRC QW. Source: Author.

Theories from the Newt model	**The process of information transaction in the operation of CRC QW**	**Comments**
The operation of a CRC is an arena of information transaction. It must be triggered by a particular type of information and the operation must be based on this particular type of information.	Yes	The development of a new wheat variety is the main issue, which triggers the collaboration. The other participants are contributing information to improve the value of this information. The entire CRC program has been drawn up based on this information, which was submitted by the GRDC.
Each participant is assumed to have its own information with its own codification, while the transaction process requires a transfer of information from one participant to others. In such a case there is a need for a translation media, this is called a translation regime.	Yes	The research providers provide particular information and maintain their codification of information transaction. For example a university participant requires part of a basic research activity prior to jumping to an applied activity. The industries put their representatives in each part of the projects. The Board of Directors provide as catalyst to convey all these differences.
The process of information transaction is dependent on the role of the translation regime. The translation regime is dependent on a particular participant.	Yes	The GRDC acts as the master, which controls the translation regime as being the participant which submits the main type of information. The projects have been linked to the GRDC's style of codification. CRC QW codification is basically GRDC's codification.
The process of information transaction is the codification of information from each participant to the CRC's codification and participant exchanges the information with other participants through an information channel which is also under CRC codification. This process must happen reflexively.	Yes	The spider diagram has shown (based on example) that many projects were successful when they were conducted through the GRDC's style of codification.
This has implication for the relationship among participants in the CRC. The participant, which submits that particular type of information may have a special role. The relationship among participant is a master to slave relationship.	Yes	The GRDC is the master. All other participants are slaves.
The information system may contribute to support the process of the information transaction.	Yes	Lotus Notes provides the platform of a single codified system of information transaction. This system has been successful in linking the scientists in their labs with the growers on their farms.
The information system may support the master to "rule" the other participants.	Yes	The Lotus Notes is a very codified method of information transaction. All types of information transacted should be set under a certain format. This simplifies the master in "mastering" the process of the information transaction, both in terms of content and value of the information.

As long as CRC's funding from the government is available[94], the GRDC is unlikely to cease the collaboration for many innovations can be created through this collaboration and given that the main type of information that is provided by the GRDC, the type of innovation which will be created will be one which is beneficial for the GRDC. The GRDC as the master also sees the need to be in a position to foresee the required codifications of the possible information activities which may happen in the future. In this case study of CRC QW, the process of information transaction and the role of the information system are as predicted by the Newt model.

7.5. CONCLUSIONS

This chapter has presented the analysis of the Newt model in the CRC QW. It has been demonstrated that there is a particular type of information which contributes to the dynamics of the entire collaborative research entity. This particular type of information also contributes to the operation of the CRC. However, there is a role of a huge organization which is in a position to master the process of transaction for the entire type of information. This organization drives, controls, and manipulates the entire dynamics of information activities in the network by controlling the process of de-codification and re-codification of information transaction in the collaboration.

The GRDC, which has been investing money for research, is in a position to have the largest information repository and thus is in a position to determine the orientation of information activity in the CRC QW. The GRDC which, has been dealing with many different types of

[94] The idea that funding may function as a way for mastering the collaboration is beyond the scope of the thesis. See section 10.3

organizations, is also in a position to understand about all the codification used and the existing multi layers of communication within and between these organizations. The GRDC, thus plays a special role in the establishment and operations of CRC QW. The development of a new wheat variety comes as the main type of information, which determines all the operation of the information transaction within the CRC QW. This type of information, submitted by the GRDC, is the generator which has triggered all participants to join the collaboration. This main type of information forms the base of the codification process conducted by the translation regime. This reveals the importance of a particular type of information in creating the dynamics of the process of information transaction. The type of information and the codification of its transaction have also determined the arrangement of the program for this CRC. The sequence of the program has been arranged so that it will accommodate the process of codification of information transaction in producing the new type of information, which must fit to the codification of information in the CRC QW especially that which comes from the master.

Understanding the codification of information exchanges supported by the CRC QW will make the industry participants adopt new layers of communication, and a new kind of codification of information; these are the awareness of research and its value for the benefit of their products. By understanding the codification of information transaction from industry and other participants, enables a better information exchange with the other participants and this will give the other participants the possibility of opening to a new research dimensions for the benefit of Australian industry and to better understand the needs of the industry. The CRC QW has created a situation where there is a better information transaction. This has been done by the development of a translation regime where the detection of codification in information activities and different layers of codification of communication can be done better. However, it has also been found, that the translation regime has done this, in favour of the particular type of information provided by the GRDC. The participants of the CRC QW have their own codifications in information activities. It has been found that their codifications have been developed based on the type of information being exchanged among themselves within their organization. The CRC QW with the task of translation regime, has to detect the codification of information activities which are used by each participant, determines the existing different layers of communication and selects the best "genotype" and brings this to other participants. This process should happen reflexively within the collaborative research network. The existence of the Internet information system has proven to be very helpful in doing and simplifying these processes. However this chapter has concluded that the Internet has helped the CRC QW as a translation regime support the master to exercise its mastership in the process of information transaction.

The Newt model introduced in chapter 5 is able to explain the process of information transaction in this CRC. The Newt model has shown that a master to slave relationship exists in the process of information transaction among participants within the CRC QW. The model concludes that this kind of relationship contributes to the successful operation of the CRC QW. The CRC QW plays an important role in this master to slave relationship. The CRC QW, has been supportive as a translation regime for the GRDC as the master.

CHAPTER 8. CASE STUDY 3: THE CRC FOR ADVANCED COMPUTATIONAL SYSTEMS (ACSys CRC)

"The ACSys CRC was formally established on October 1, 1993. The core institutional participants are the Australian National University (ANU), as the university component and the CSIRO Division of Mathematical and Information Sciences (CMIS) as the Public Sector Research (PSR) Agency component". (ACSys Annual Report, 1997/98, 1998:p 4) "The core industry participants are Digital Equipment Corporation Pty. Ltd. Australia (referred to as DEC), Fujitsu-Australia Pty. Ltd. (referred to as Fujitsu), Silicon Graphics Institute Australia Pty., Ltd.(referred to as SGI), Storage Technology of Australia Pty., Ltd. and Sun Microsystems Australia Pty., Ltd. (referred to as Sun)". (ACSys Annual Report, 1997/98, 1998:p 4) The structure of this CRC is given in figure 8.1 (see next page).

A brief introduction to these four large organizations[1], which later will be called giants, is as follows. "The SGI is the world's leader in high-performance computing technology, dedicated to unleashing the power of human creativity"[2]. "The company's systems and products, ranging from desktop work-stations and servers to the most powerful supercomputers in the world, deliver advanced computing and 3D visualization capabilities to scientific, engineering, and creative professionals and large enterprises"[3].

"DEC-Compaq Computer Corporation, is the largest supplier of computing systems in the world. DEC-Compaq designs, develops, manufactures, and markets hardware, software,

[1] A more detailed description for these participants is given in Appendix 7.
[2] http://www.sgi.com/company_info/ retrieved at December 12, 2000.
[3] Ibid.

solutions, and services, including industry-leading enterprise computing solutions, fault-tolerant business-critical solutions, and communications products, commercial desktop and portable products, and consumer PCs"[4]. "DEC-Compaq products and services are sold in more than 200 countries directly to businesses, through a network of authorized DEC-Compaq marketing partners"[5].

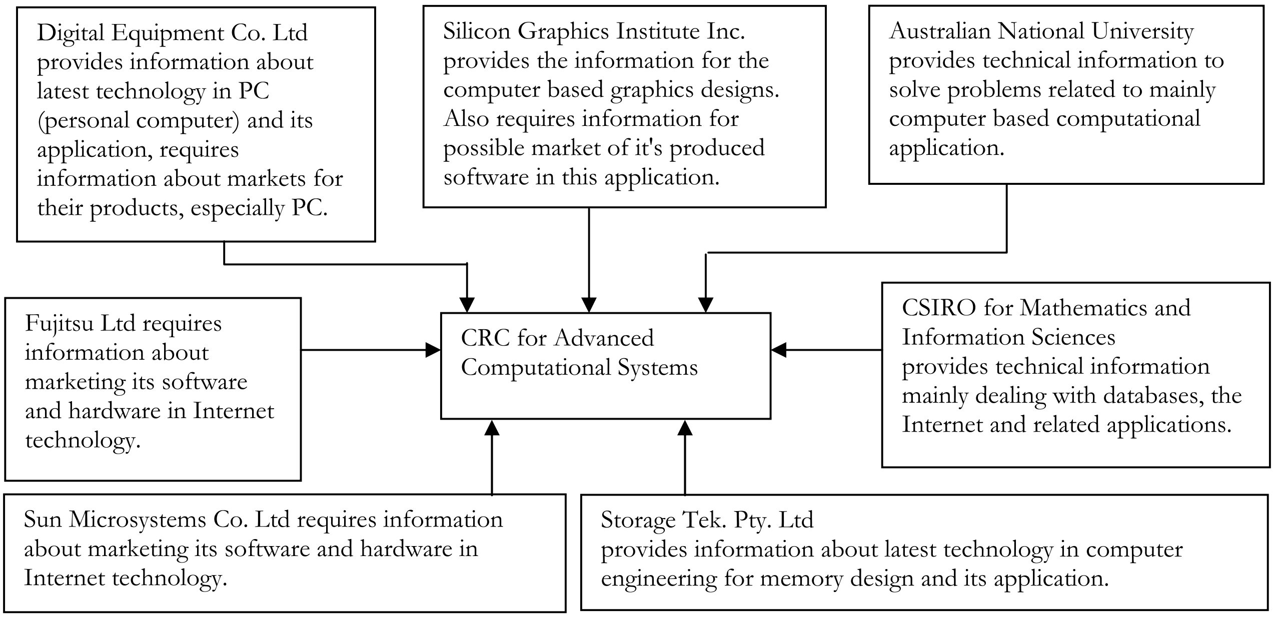

Figure 8.1. Participants of the ACSys CRC.
Source: Author, compiled from several ACSys CRC Annual Reports and interviews.

"Fujitsu is one of the world's leading e-Services organizations"[6]. "Its major business is manufacturing and selling of softwares and services, computers and information processing platforms, telecommunications systems, semiconductors and electronic devices world wide[7]. Fujitsu is one of only two companies worldwide to achieve a top 10 ranking in information technology, telecommunications and microelectronics"[8].

4 http://www.compaq.com/corporate/community/ataglance.html, retrieved at December 8, 2000
5 Ibid.
6 http://www.fujitsu.com.au/about/profile/index.htm retrieved at December 8, 2000.
7 http://pr.fujitsu.com/en/profile/profile.html retrieved at December 8, 2000.
8 http://www.compaq.com.au/solutions/govtedu/education/ retrieved at December 8, 2000.

"The last of these large companies is Sun Microsystems, Inc., this is one of the world's leader in network computing products and services[9].Sun provides systems, software, storage, support and services - not to mention platform-independent Java™ and Jini™ technologies - that power the Net for business"[10]. "Sun's product line now encompasses workstations, servers for workgroups, departments, mainframe class servers, mass storage systems, system software and network management solutions"[11].

Another participant, which can be categorized as giant (but slightly smaller than the previous four large companies) in this information industry is[12]: StorageTek. This company delivers a broad range of storage solutions for digitized data. "StorageTek solutions are easy to manage and allow universal access to data across servers, media types, and storage networks. StorageTek is the innovator and global leader in virtual storage solutions for tape automation, disk subsystems and storage networking".[13]

The other two strategic members of ACSys CRC are the research providers. These are CMIS and ANU both are located in Canberra and their locations are very close to each other. The CMIS activities are dealing with solving problems across a wide range of industries using its skills base and the results of its research in information technology, mathematics and statistics[14]. The main research interests of CMIS are: Software and Component Architectures, Bioinformatics, Digital Media Information Systems, Intelligent Interactive Technologies and Image Analysis[15]. The ANU is quite a large university with extensive

---

9 http://www.sun.com retrieved at December 14, 2000
10 Ibid.
11 Ibid
12 http://www.storagetek.com/about_us/, retrieved at December 11, 2000.
13 http://www.storagetek.com/about_us/, retrieved at December 11, 2000.
14 http://www.cmis.csiro.au/, retrieved at April 19, 2000.
15 Ibid.

research activity. The ANU mobilizes the following departments for ACSys CRC: The Department of Computer Science[16], Computer Science Laboratory[17], Centre for Mathematical Analysis, and ANU Super Computing Facility.

The objectives of the ACSys CRC are: (1) to combine and integrate the resources of the participants for mutual benefit; (2) to conduct world class research and development in advanced computational systems; (3) to deliver benefits to Australian industry, science and the economy; (4) to conduct communication and education programs of international quality; (5) to manage the resources of the Centre effectively and efficiently. (ACSys Annual Report 97/98, 1998, p: front overleaf)

Those four large companies (except Storage Tek) will be called giants. These giants team-up in this ACSys CRC with ANU and CMIS, and several smaller industries to achieve the objectives of this CRC. To conduct such an effort the ACSys CRC develops five research activities as follows: "(1) Advanced Server Technologies; (2) Data Mining; (3) Digital Media Library; (4) On-Line Data Archives; (5) Virtual Environments. (ACSys Annual Reports, 1996/97 to 1997/98) The overall theme of the ACSys CRC activities is *Managing the Information Explosion.* " (ACSys Annual Report 97/98, 1998, p: 7) This reflects its focus "on the integration of advanced technologies-rapid information access, large-scale data management, high-speed computation and broadband networks to handle ever increasing amounts of information". (ACSys Annual Report 97/98, 1998, p: 7) The ACSys CRC has also two more the so-called Special projects: these are projects which are conducted in order to support the previous flagship programs. The special projects are: "(1) Network Modelling,

[16] This Department is Under Faculty of Engineering and Information Technology.

Abstraction and Parallel Processing and (2) Advanced Co-operative Research Network". (ACSys Annual Report 97/98, 1998, p: 7-8) In table A.7.1 the programs of the ACSys CRC are given in more detail and also the proposed specific target for each program[18].

The organization of this chapter is as follows: section 8.1 discusses the establishment of this CRC from an information perspective especially the investigation of the crucial type of information, which triggers the entire collaboration. Section 8.2 discusses its operation from an information perspective, most importantly the investigation of the relationships among participants and the role of the information system in the operation of the CRC. Section 8.3 discusses the application of the Newt model to explain the process of information transaction in this CRC. Section 8.4 discusses to what extent the Newt model works in this particular CRC. Finally section chapter 8.5 describes some important conclusions.

8.1. THE ESTABLISHMENT OF ACSys CRC FROM AN INFORMATION PERSPECTIVE.

This section describes the establishment of the ACSys CRC from an information perspective. The main objective of this section is to identify the critical type of information, which has triggered the collaboration and how this type of information flows in the collaboration network. This discussion is necessary because the Newt model introduced in chapter 5 was derived from an information perspective. In order to identify that critical type of information within this collaborative research partnership, the following approach is used:

---

[17] Under Research School of Information Sciences and Engineering (RSISE).
[18] Table is complied from data in ACSys CRC Annual Reports, 1997/1998 and http://acsys.anu.edu.au/ retrieved on November 14, 2000.

(1) from where the information is coming; (2) what type of information drives and gives birth to this co-operative research centre; (3) how does it come there and (4) how is it used.

The main actors in this interest are four giants in the information industry. These are DEC, SGI, Sun and Fujitsu. Table 8.1 (next page) lists the roles of the four giants in the ACSys CRC from an information perspective. Three of these 4 large companies are competing against each other[19] because they deal with exactly the same type of products and services (software part of information industries). These three giants are DEC, Fujitsu and Sun. In fact SGI also deals with the software part of the information industries, but this company is more specific in the development of software for graphic design applications. Meanwhile DEC is also an information industry, but it deals more with the hardware part of it. Thus there is a close interest by these four giants which brings them together to form a collaborative research partnership. In general the main intention of the organization by joining and contributing to the ACSys CRC is to get access to the technological type of information. The following two quotes from two representatives of two ACSys CRC participants illustrate this:

> The most important reason for joining this collaboration is to get access to this, type of technological information[20].
>
> The most fundamental type of information is technical (technology and science). Without this they will have nothing to offer. The next most important thing is networking information: that is such as business intelligence to find new potential partners or users[21].

[19] Interview with Mr. Greg McCane, Executive Director of DEC-Compaq Australia Pty., Ltd., also member of Board of Directors ACSys CRC, March 29, 2000.
[20] Interview with Dr. Graham Reynolds, Australian National University (university's partner), Program Coordinator for Digital Libraries, November 18, 1999.
[21] Interview with Mr.Peter Milne, CSIRO-CMIS (public sector research partner), Leader of Data Mining Program, November 9, 1999.

Table 8.1. The role of the giants in the establishment of the ACSys CRC.
Source : Author compiled from sources from websites and interviews

Name of Organization	Role in ACSys CRC
Silicon Graphics Institute Australia Pty.Ltd.	Mastering information capacity including its codification and channel of information flow in the field of software for graphics and visualization application.
DEC-Compaq Australia	Mastering information capacity including its codification and channel of information flow in the field of hardware of Personal Computer sales, services and operation.
Fujitsu Australia	Mastering information capacity including its codification and channel of information flow in the field of (mainly) software and hardware for the Internet and other networking applications.
Sun Microsystems Australia	Mastering information capacity including its codification and channel of information flow in the field of (mainly) software and hardware for the Internet and other networking applications.

Furthermore, by joining the ACSys CRC both the giants plus other 35 smaller companies, have adapted to the new trend of the world economy, that is, by making their researches closer to customers and users.

The giants have been in Australia for a long time. It must be noted that the giants in this analysis refer to the companies and not to their Australian branches. The giants are in possession of an information about the Australian information industry including its codification. They have been deploying their products and services for years to the Australian community and they have created a chain of users and suppliers of these products (and services). The Australian government itself is part of their market segments. The Australian government for example has been using products and services of Sun for a long time. The Australian government also requests Sun to help in the development of the Australian information industry and to facilitate exports. The following quote from a Sun representative illustrates this point:

> We were invited by the ANU to join the ACSys CRC program. And, I suppose, as our main background, Sun is a multi national company operating in Australia. The Sun Microsystems is a member of the government partnership development program. In fact, we do 99% or 95% of our research in Sun labs in California so we found then, that the CRC program which was new, was a good program to encourage the existing research organizations, like various universities, CSIRO's and local companies to collaborate. And secondly if whatever assistance we gave to this CRC, in terms of money and technology would be a good investment and would be good to help this CRC and also to help meet some of our obligations to the government partnership development program[22].
>
> And what we had undertaken was to invest a certain amount of money in research and development activities in Australia and to help facilitate Australian exports in the information industry[23].

The same applies to the other giant, the DEC. This company is interested in the ACSys CRC only to get commercial benefits without trying to become more innovative by using CRC researchers provided by the university and the CSIRO. DEC has been selling computer hardwares to the Australian government agencies and providing services to them. By joining the ACSys CRC DEC has been able to strengthen its position and to get more access to winning more tenders for more procurements from both government agencies and other government affiliates, as the Executive Director of DEC points out in the following quote:

> The benefits should accrue to us. In the early days, there were partnerships for the development program that had benefits for assisting DEC in its doing business with various Australian government agencies. So this was investment in R & D in Australia which helped to win our business with the Australian government. Today, apart from indirect benefits of winning government businesses and projects in Australia, we haven't got any other benefit from our investment in the ACSys CRC[24].

The SGI as the other giant has a similar intention as indicated by the representative of this company as follows:

> I became involved because I had to do a lot of work associated with maintaining relationship from a financial view points. The reason why we did that was because they had made a decision that CRC for Advanced Computational System is needed to consider high in graphics, as part of their backtrack, so to speak. And because we

---

[22] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.
[23] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.
[24] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.

> are in the frontier of the high graphics company in the world, there was a reasonable match. So, the reason why we joined was because of the discussion we held and the reason why the discussions were held were because of the nature of the products that we manufactured and sold here in Australia and the need for potential research activity that the CRC wanted to do with our organization workhouse[25].

The main intention of SGI to join the collaboration is thus to strengthen its position in the Australian market (see above quote). The type of information, which drives this organization to join the collaboration, is market information in Australia because Australia is one of their largest markets[26]. The other driver for the giants to join the collaboration besides looking for information about the market is also to look for the IP, whether it can generate commercial benefits for the giants. The following quote from the DEC Executive Director illustrates this point:

> Essentially we do not have a joint project. The way we have been working to date is that ACSys CRC will run the project and generate some IPs and then DEC will evaluate that IP, whether we believe that it is of commercial profit to us[27].

These giants, such as Sun, Fujitsu, DEC and SGI support the ACSys CRC to get the type of information about market opportunities in Australia. These giants have been operating in Australia for years, their systems and equipment have been used by nearly all Australian government offices and business sectors. These giants are not interested in getting information about using this CRC to develop the leading edge of technology and/or technological excellence in Australia. These giants are joining this CRC because they are only interested in helping market their products and services in Australia by using the ACSys CRC as part of such a mechanism. See for example the following quote from one of their representatives:

> However, in the case of the CRC, we were involved, in the way that relates to the CRC and to the market place is probably being influenced by the CRC. We were

[25] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[26] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[27] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.

> involved not in the research sense but in the more commercial sense. We are more as a provider of resources rather than as a research partner[28].

The participant from PSR is also looking for a technical type of information related to a particular problem, as indicated by the following quotes (from CMIS people):

> The ACSys CRC has Sun, Silicon Graphics, DEC and Fujitsu as their clients. Because these four are giants in computer technology, these companies, to some extent, do not believe in the ACSys CRC researchers. They conduct their own researches in their own laboratories in the USA and Japan. And they use ACSys CRC only as a kind of marketing arm for themselves rather than as a true research partner.
>
> We ask the industry to provide us with some advanced computational system and software in order to work out the problems from other clients. Such as Sun provides ACSys CRC with the latest model of a computer network and SGI provides ACSys CRC with some latest software and hardware to anticipate problems in data mining[29].

For the ANU Department of Computer Sciences and CMIS the main ideas behind promoting this CRC is actually to collect a particular type of information, in this case technical information and the way this can be applied to business activity and the market especially in Australian markets. See for example the following quote from a representative of CMIS:

> The main agenda of the CRC program is to make the technology, to make people aware of this technology and the capability of this technology. Doing this will make the local business easier and marketing better. So the most important reason for promoting this CRC collaboration is to get access to this information technology and to get information as to whether this technology is beneficial; for local business and can be useful for their business and to solve their problems[30].

Thus the secondary driver for the setting up of the ACSys CRC is caused by the need from the research provider's participants (ANU and CMIS) to strengthen their information capacity in information technology and how to market their expertise. To summarize there are two types of information which, have given birth to the collaborative research

[28] Interview with Mr. Bob Mounic, Director Business Development System, Sun Microsystems Australia, Pty., Ltd., March 17, 2000.
[29] Interview with Mr.Peter Milne, CSIRO-CMIS (public sector research partner), Leader of Data Mining Program, November 9, 1999.
[30] Ibid.

partnership at ACSys CRC: The first is market information, especially information that will expand access to market products and services to Australian customers. This type of information dominates the establishment of this CRC. The second type of information, is the technological excellence to solve the problems encountered by industry by using the computational systems and its applications. This second interest originates from Australian research providers. The second type of information is of much lesser importance than the first. The next section discusses how the participants are transacting the information in this CRC.

8.2. THE OPERATION OF ACSys CRC FROM AN INFORMATION PERSPECTIVE

This section discusses the role of the critical type of information in the operation of the ACSys CRC. The main objective of this section is to discuss the process of information transaction of types of information introduced in section 8.1. in the operation of the ACSys CRC. This topic is outlined in subsection 8.2.1. This subsection also discusses the implications of such a process to the relationship among participants. The role of the information system in this CRC is outlined in subsection 8.2.2.

8.2.1. THE PROCESS OF INFORMATION TRANSACTION

In general the main objective of the CRC program is to bring together both designers and customers into a single entity to collaborate in order to create a marketable innovation. In the ACSys CRC such a thing is anticipated, by making all participants get closer to each other. The participants as have been explained in the previous chapters, are different, both in the level of information capacity and in size. The giants (DEC, Fujitsu, Sun and SGI) are the participants, which have the largest capacity of information. These four giants may have a special contribution to the process of information transaction in this ACSys CRC.

Therefore the type of information, which is submitted by the participants to the information mixing pot is basically under the strong influence of those four giants. This is because the giants deliver information to the other participants of the ACSys CRC (from smaller industries), universities (ANU and later UTS) and CMIS while the giants in return require market information.

For Sun, such an intention for market expansion is understandable because many of the participants of the collaboration have been using Sun's technology and thus all information is subject to being controlled by this giant (Sun) for the collaboration itself is in information industry. Furthermore the strategy of this company today is a process that must match the situation of the market, therefore it is usual, when Sun tries to achieve this by using the ACSys CRC. For the giants this CRC is their "detector" of the market-situation. The following quote from a representative of the giants illustrates this point:

> What we do is: we have contributed in a number of ways. What we have done is, that we have made equipment available to this ACSys CRC, a very high and specialized equipment at extremely price process capability. The second way that we have done is that we have offered them scholarship; the third way what we have done is by providing interaction with people who they would like to have interaction with, in other words provide the glue for a network[31].

From the above quote it may be implied that the giants may completely determine the codification of information transaction, for all the equipment and facilities are provided by them and this equipment is highly specialized. In fact, nearly all other equipment related to

[31] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.

information technology used by participants, are the products from either Fujitsu, Sun or DEC.

Furthermore, the giants themselves are expecting, that by making all the ACSys CRC people are using this equipment which is all of their products, enables them to know more about the required services and the better products to anticipate problems. Therefore, the main codification in information transaction is about market information especially related to product and services required by the users (because most of the participants are users of equipment supplied by giants).

The other important codification for information transaction used in this CRC is set up by government; this is because the largest part of funding is given by the Federal government. (ACSys CRC Annual Reports 1996/97 to 1997/98) The giants to some extent consider the second codification as unique. See for example the following quote, which is given by a representative of the giants:

> Now what is unique about the CRC is that government has been providing significant funding to facilitate and to encourage other organizations such as industry, academia, research institutes to contribute to the resources and skills required to carry out the research. I guess the unique thing about the CRC is, yes the co-operation, the collaboration and the mixed research team etc., but to make it quite unique or separate is the government initiative and government is providing substantial funding and resources to make that happen[32].

The following quote reveals the main objective of the giants which is to pursue such a goal and their commercial intention, to expect that at the end of the project, all the participants of the ACSys CRC would be the users of the equipment produced by them, which also means to include them into their 'system' of information codification:

[32] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.

> Our benefit arises in a much more oblique way. It comes from the CRC participants developing their skills and abilities. They are able to influence down stream people who will be doing more applied things, and at the end, they will be the procurers and the users of our equipment[33].

Therefore from the perspective of the giants given they are using "market" as their codification in communication with others, they tend to put all participants from their perspective of this market's codification. Furthermore these four giants themselves, given their position as participants of the ACSys CRC, are also submitting information to the "information mixing pot" and the mixture is the type of information, which is used to control the ACSys CRC operation and activities. This mixture is thus information provided by the ACSys consortium plus information from these four large industries. The second part has more interest in the market and opening the gate to market their products and services in Australia.

As noted, some of the giants themselves are competing against each other. These are DEC, Sun and Fujitsu. These companies are dealing with the same business, more specifically in the manufacturing of equipment for computer networking and servicing of all those parts which are dealing with networking technology. The rivalry between these giants makes the process of information transaction in the web of collaboration become more complicated as indicated by a representative of the giants in the following quote:

> In ACSys there are a couple of participants who are definitely being considered to be competitive to DEC, which have been Sun and Fujitsu. I do not think, it is a particularly good model to have a CRC which has multiple participants who are competitive in the open market places[34].

[33] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[34] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.

The information mixing pot thus also includes information, which is dealing with the rivalry between companies. Given that rival companies are giants, this may affect the process of information transaction conducted by participants to exchange the information.

From the previous discussion it can be concluded that there is a strong codification of information delivered and required by each participant. The transaction of this information is also under a well-codified process and moreover some participants of this collaboration are in horizontal competition. As shown in the previous chapters, there is a need to have a translation media which will translate this codification into a single ACSys's CRC codification. This media is realized through the Board of Directors and the process to conduct such a translation is to use a formal regular meeting which is attended by participants of this CRC to discuss the project contracts. The Board of Directors meets quarterly. (ACSys CRC Annual Reports 1996/97 and 1997/98) The three following quotes illustrate the method of information transaction in this ACSys CRC:

> The main core of the program organization is using a formal regular meeting. The first phase of this regular meeting is with a steering committee which will also monitor and will keep the project on track. The second phase of a regular meeting is with the program manager to discuss the specific project. The program manager will conduct the third phase of a regular meeting with the researchers within the departments. The follow up of this regular meeting is done by using electronic mail. Video conference is also used for a regular meeting with the participants which are located far away, to minimize the cost[35].
>
> The Board of Directors meets regularly 4 to 5 times a year. The executive which, is much smaller group meets monthly or as required, and the heads of the research team meets at least monthly as well[36].
>
> The interaction between people in our CRC is done at various levels. At an executive level it is usually done by written material, that is traditional written material, with the fax and also by using e-mail, which is a regular information transfer mechanism. There is some level of tele-conferencing at the most technical level. E-mail is the

[35] Interview with Dr. Graham Reynolds, Australian National University, Program Coordinator for Digital Libraries November 18, 1999.
[36] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.

> most dominant information transfer mechanism, occasionally we also have face to face meeting[37].

From these quotes it can be concluded that the information transaction is thus using formal meetings which are conducted on a regular basis. The need to monitor the entire project reveals the industry's need to make sure that everything in the information activities is included within their codified format. The meeting itself is an arena where all issues from different perspectives, such as from the users, supplier, and research providers are discussed, as indicated in the following quote:

> One of our policies is that as far as possible we want the research team from different research organizations to come together in a regular meeting or part time meeting to solve particular problems in the line of research. And at a working level there are formal and regular and continuing contacts between the individual and organization as well. The CRC itself provides substantial opportunities for cross research project communication so that one team working in data mining would also be made aware of what work is being done in the visualization area. So that, for example, they could benefit from that innovation from other areas and possibly use some of it in their own project and that is done very consciously and in a structured way[38].

In these meetings the following issues are considered[39]: (1) making the technology, (2) making people aware about the need for this technology and its existence (3) making people aware of the capability of this technology. Doing this, by taking all participants of the collaboration is not only making business easier but also makes marketing better because there will be a match between codification of user and suppliers. This way of working is also very conducive to creating innovation because all participants contributing to the process are being taken into one single table. This way of working also brings the researchers closer to the customers and the future users and market of their research results. This meeting is also

[37]Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[38] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.
[39] Interview with Dr. John O'Callaghan, CEO, ACSys CRC, November 30, 1999.

to evaluate the operation of information transaction on a formal regular basis[40], which is, once a month on a top level (Board of Directors) and once a week on an operational level (program leaders with their researchers).

The other method of information transaction (besides regular meetings) is using an education program[41]. This program includes sending people to conduct a technical visit to overseas, postgraduate student support program (including fellowships), summer scholars (open to all students) and numerous course/seminars and workshops which allow them to be better indoctrinated into the giant's codification system. These two channels of information aim to help ease the process of commercializing the research results conducted at the ACSys CRC. The role of information system in the process of information transaction by using these methods is discussed in the following section.

8.2.2. THE INFORMATION SYSTEM AND INFORMATION TRANSACTION

To support the process of information transaction, the ACSys CRC is employing and using the Internet information system and its application quite extensively. It is interesting that all of this equipment for the Internet is produced either by Sun or Fujitsu[42]. The usage of the Internet besides for communication is also to support the research itself because the research's main interest in this ACSys CRC is in dealing directly with information technology. For example the graphics research (promoted by SGI), with the Internet, it can

[40] Interview with Mr.Peter Milne, CSIRO-CMIS (public sector research partner), Leader of Data Mining Program, November 9, 1999.
[41] Interview with Dr. John O'Callaghan, CEO, ACSys CRC, November 30, 1999.
[42] Interview with Dr. John O'Callaghan, CEO, ACSys CRC, November 30, 1999.

be conducted on-line and enables the research to become easier to conduct than before. The following quote from a representative of SGI illustrates this point:

> We are a graphic company, because of that visualization is very important. Information exchange mechanism with the Internet, at a certain level is that people are able to merge themselves in data shelf. So in a way that information exchange mechanism is the exchanging of scientific information that you can regard as the research outputs or it is actually at way in which information is exchanged. Thus visualization merged visualization is the way information is exchanged by the Internet[43].

The importance of the Internet is generally regarded as quite significant in this CRC, the following quotes from three different representatives of the ACSys CRC participants illustrate this point:

> We use the Internet quite extensively. And I think without the Internet the performance of this ACSys CRC collaboration will decrease[44].
>
> Yes, the Internet is important and did improve the performance of the organization. Most notably is that the Internet could reduce the travel cost significantly. The laboratories are mostly located in Canberra but the clients are mostly located in Sydney, using video conferencing [one of the Internet's applications] greatly reduces the cost of travel. We use the Internet quite extensively. For example: e-mail is used not only for sending letter but also sending reports, for data analysis and drafts of important research results. If we want to start a project we will make an e-mailing list with addresses of all participants of the project are registered in this e-mailing list. We also use the Internet to do data analysis and research work. For example we make their main computer system accessible to remote areas to enable researchers from those areas using this system. We are also using the Internet to market the research results internationally and to join international projects[45].
>
> Yes, the Internet is important and does improve the performance of the organization. The Internet is used quite extensively. E-mail is used for an extensive communication and the Internet application is also used as a method of software development. Without the Internet application the performance of the department will be downgraded[46].

The above three quotes again reveal the fact that the Internet in this CRC is not only used as a means of communication but also for doing research and thus the Internet dominates the

[43] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[44] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.
[45] Interview with Mr.Peter Milne, CSIRO-CMIS (public sector research partner), Leader of Data Mining Program, November 9, 1999.
[46] Interview with Dr. Graham Reynolds, Australian National University, Program Coordinator for Digital Libraries November 18, 1999.

entire process of information transaction on this CRC. Meanwhile, the giants are the producers of the Internet technology and its applications. Thus an extensive usage of the Internet may mean that the giants are in a position to codify the process of information transaction. Being in such a position, enables the giants to control the entire web of collaboration by controlling the operation of the translation regime in translating the codification of each participant. The giants in this matter will make sure that the translation regime in translating the codification is focused for their benefit, that is, to get more market access for their products and services. Moreover to make sure that they can make people become aware about their technology and to get attracted to using their technology and at the same time penetrate the market of smaller businesses and make sure that they will procure more of their products and services in the future.

As in the previous two CRC case studies, the Director of this CRC has to function as a translation agent. The participants are invited to join in regular meetings to address important issues in order to help translate the different codification into their own codification or "language". Unlike the two previous CRCs, in this CRC such a role is difficult for the Director to conduct, given that the giants themselves are within a horizontal competition. The following quote from an industry participant illustrates this problematic situation:

> What the CSIRO has been doing is business of research. What I am saying to you is, that they are in the business doing research. So I would say, I think at a fundamental level their interest is in pursuing a research career, pursuing a research activity. Their fundamental reason for being in the CRC is not solving our problems and they cannot anyway. Their business is in the business of doing research, writing papers, and selling papers[47].

[47] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.

The translation regime in this case does not work for connecting the CMIS with the SGI as can be seen from the above quote. For SGI (one of the giants), especially from their perspective, the business of research providers is not to help them solve technical problems but to seek business for their own benefit. For the SGI, the activity of the CMIS and ANU as research providers, is also a business, but they are doing business of a different kind, they are not marketing their products and services but their research. The following two quotes reinforce the above objective:

> We are a company in the business of pushing the visualization to the limit. Yes, and we do that as commercial purposes, we sell our products to all over the world. These people from CMIS are doing research work in terms of visualization. They are doing work in hectic devices and so forth. We do work on hectic devices, but we are not going inappropriate or unnecessarily to devote to their research activity than we do. But CMIS are under us. We are doing so, so that we can sell our products to CMIS, okay[48].
>
> As far as I can see is in this CRC, that I think a significant element of this CRC, are academics who are looking for specific problems and want to solve them, and that is not necessarily, what industry wants to solve[49].

The previous quotes are examples where the translation regime is unable to translate the codification from the research providers to SGI. The Director as the agent for this translation regime is in a difficult position because the services and products used by him, are fully controlled by the giants. SGI for example controls all software for graphics application and usage to nearly all of the projects conducted at the ACSys CRC, which have a relationship to the graphics development and applications. The same applies to the DEC-Compaq computer, which provides nearly all the hardware for the entire ACSys CRC collaborative network.

---

[48] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.
[49] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.

The giants deal with the information technology and this CRC deals with the same interest. Having a well-formalized information transaction will be beneficial for the giants. The work at CRC allows the giants to impose more control by creating a very well codified information transaction mechanism. This will make the type of information being exchanged to be completely determined by the giants. The giants can obviously limit them for their benefits especially to secure the giant's market positions in Australia. The giants, who possess a much larger capacity of information, are in such a position to control what type of information is being exchanged in this collaborative network. The process of information transaction is thus totally dominated by the giants and there is no equality in information transaction from research providers such as CMIS and ANU and other universities, because the giants are much stronger in terms of information capacity compared with other Australian research providers. Basically this is the way information is being transacted in the operation of the ACSys CRC and this is the mechanism of information exchange which both the industries (including the giants) and research providers are doing towards innovation.

However, the information created from this information activity can deliver several benefits. For the university's participants, this new type of information can be used to increase their information capacity and open new fields in basic research in computational technology. Collaboration with the ACSys CRC has contributed resources which enhance the computing and communication infrastructure on the ANU campus. (ACSys CRC Annual Report 97/98, 1998, p: 8) The new type of information has been able to give more topics in the teaching program within the Department of Computer Science, the Faculty of Engineering and Information Technology and Centre for Mathematical Analysis. (ACSys CRC Annual Report 97/98, 1998, p: 8) However, the ANU is becoming part of the giant's codification system of information transaction given that the ANU has been doing all their research activities by using software and hardware supplied by the giants. Thus all the innovation and information exchanged are under the giants' codification.

For the CMIS this new type of information is used to open a new dimension into a new kind of research in computational technology that is leading to new innovation. Both the CSIRO and university participants are also benefiting from the in-cash contribution from the industries to help increase the information capacity of their research. For the giants this new type of information is used only for helping them to expand the market for their products in Australia by creating such an environment where all information activities will be under their codification.

However, it is interesting to note that the giants do not find that they have become more innovative by joining the ACSys CRC program. See for example the following quote from an Executive Director of DEC (one of the giants) which illustrates this point:

> Well, I don't think that our company become more innovative due to our relationship with the CRC[50].

The same person also notes that the type of information mixed with other types of information in the information mixing pot, does not contribute anything to his company as given in the following quote:

> There may have been some new ideas generated that we have used, but there is no, sort of, direct, or there is nothing that I can point of, that is a software or any other benefit which is a lot of better, because of some information that we have got from our relationship with the ACSys CRC[51].

[50] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.
[51] Interview with MrGreg McCane, Executive Director of DEC Compaq, Australia, Pty, Ltd., March 29, 2000.

DEC, is one of the giants which only has interest in expanding the market in Australia and the above quote reflects that this company has never been interested to gather any type of information related to technological excellence. The other giants also never expect to get much benefit in terms of getting more types of information that can increase their technological excellence by joining the ACSys CRC. The following quote is from a representative of another giant, the SGI:

> But if you do ask me, did we get benefit some way, which our organization fundamentally changes its capability, because of the research activity of ACSys CRC? Well, I have to fully say, no[52].

For Sun, being one of the world's largest companies in this field, there is no need to get any type of information related to technological excellence to increase their information capacity by using the ACSys CRC. The following quote is from a Sun representative and illustrates this point:

> We did not go into the CRC because we were interested in pursuing a specific line of research and innovation, okay. So, we did not join the CRC because we want to do research into large-scale data mining particularly. Our first decision was based on, this is a new program, so we would like to be there to help and assist and guide the CRC[53].

Thus the ACSys CRC is in a position to operate in such a way, that an environment where mutual benefit for all participants from an information perspective cannot be realized. For the giants, given that most of the leading edge activities are being conducted in their home countries, there is no way that they will be attracted to share their information related to technological excellence with an Australian participant. The giants, from this information's perspective, want to keep their information limited to market information only. Moreover they may strive to create a very codified environment for their market in order to secure

[52] Interview with Mr. Andy Wyatt, Director of Business Development, Silicon Graphics Institute, Pty, Ltd., March 16, 2000.

their positions and this can include any kind of information transaction. The information which is exchanged is thus only for the giant's benefits, because they can get all the required information from their customers rather than giving the technological excellence or sharing that with their Australian participants. For this type of information (technological excellence) the giants keep it in their repositories. Thus the new type of information from the information mixing pot has a very strong market character because of the high content of influence from the giant.

An example is the project Digital Media Library. (ACSys CRC Annual Report 97/98, 1998:p 15) This project is focused on the management of information assets and their accessibility to on line scenarios such as through the Internet, corporate networks and other forms of interactive networked services delivery. (ACSys CRC Annual Report 97/98, 1998:p 15) This focus on information access and delivery is also manifested in the creation and development of business models linked to valued added information services and products. (ACSys CRC Annual Report 97/98, 1998:p 15) This program has been investigating, developing and demonstrating innovative technologies that are particularly relevant to digital media libraries and on line information services. (ACSys CRC Annual Report 97/98, 1998:p 15) The project has in total 19 participants, including 3 giants (Sun, DEC and Fujitsu), 1 university (ANU), 5 Government agencies and the remaining 10 participants are SMEs. (ACSys CRC Annual Report 97/98, 1998:p 15) As the project's objective suggests this work has to be linked to the Internet in order to provide an interactive operation between client and server. The Sun is the leader in this particular networking technology. Sun is one of the world's largest companies in Internet products and services both in software and hardware. This project has

[53] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.

been helping Sun to introduce its systems, products and services to small and medium Australian industries which have never used the Sun system before. See the following quote:

> The effects of this Digital Media Libraries project is operating at the cutting edge of many IT projects because they are using some Sun technology to carry out that research in Digital Media Libraries and also because it has involved many local Australian companies. This definitely is a combination of activities which help Sun's image in the country. It also helps Sun communicate to the market place what is most likely to be happening in the future[54].

The innovation process at ACSys CRC from an information perspective is thus limited and controlled by the giants. This will make the process of innovation itself be driven by the giants. However, there are some aspects, which must be considered with respect to the nature of the information itself. Firstly, the information is required to be refreshed and this can only be done by allowing fresh information to come in from outside. And secondly, a basic observation is that the information must be given if new information is to be received. These facts, may force the giants to allow part of the process of information transaction to be conducted "free of their hand".

However, once the mixture of this information may create innovation, it will be directly converted into the giants' own codification, so that the innovation can deliver a direct benefit to the giants especially to strengthen their position in the market place. It is likely that the giants will monitor the process of innovation conducted at the ACSys CRC, so that once the process of innovation has been finished, the result is available for use by the giants. This new innovation will enable the giants to better prepared in the creation of new products and anticipate possible new problems. Should such a situation can be created and maintained, the giants will obviously get a huge benefit given the innovation will be created within their codification. The new type of information generated from the process of information transaction in this CRC is thus mainly information about market security for the giants and if there is a possibility for innovation, it will be limited to the market security for the giants. The next section 8.3 presents a deeper discussion in the process of information transaction by application of the Newt model to this CRC.

8.3. THE "NEWT" MODEL IN ACTION: CASE STUDY 3, THE ACSys CRC

This section analyzes the application of the Newt model to explain the process of information transaction in the operation of case study 3, the ACSys CRC.

The establishment of the ACSys CRC from the Newt model can be explained by using the analytical figure 8.2. The type of information submitted by the university, PSR and other industry participants to the application for a CRC is strongly influenced by inputs from the four major participants (the giants), because these participants are the major contributors to the establishment of ACSys CRC and these participants have been involved in so many business and services both to the Australian government and the private sector. As shown in Table 8.1, these companies have mastered the information capacity including its codification in their respected field and they have the largest capacity in the Australian markets. For these giants, involvement with the ACSys CRC is beneficial to secure their markets and given that some of them are competing against each other, the resultant input of information which is submitted for the application of this CRC is strongly influenced by their interests especially with respect to their markets in Australia.

[54] Interview with Mr. Bob Mounic, Director Business Development System, Sun Micro systems Australia, Pty., Ltd., March 17, 2000.

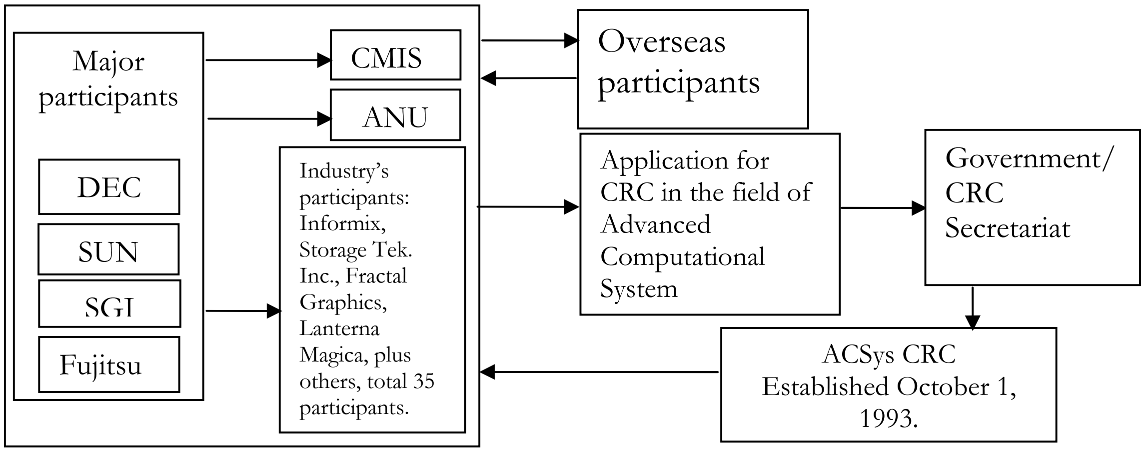

Figure 8.2. The establishment of the ACSys CRC from Newt model perspective. Source: Author.

These giants knew exactly the real situation in Australian market, however they needed to tap into the dynamics of these markets (figure 8.2). They also submitted a type of information in the development of the proposal for CRC. The resultant proposal was thus a mixture of information from the four giants (the big companies) and information from the university participants (ANU), PSR (CMIS) and 35 other smaller companies (compared to the giants) in the computer systems technology and information industry. The type of information submitted by industry mostly had the character of market information while from the university and especially from the 35 smaller companies it was of a technical matter (how to use information technology to solve their problems). The proposal then went to the government (CRC Secretariat). The government approved the proposal, and the ACSys CRC was officially created on October 1, 1993. In the first two years of its operation, several overseas participants joined this CRC.

From the Newt model the process of information transaction in the operation of the ACSys CRC can be depicted in figure 8.3 (page 265). For the giants this collaboration is part of their program to introduce new products and services and to strengthen their already strong positions in the Australian markets. This can be achieved, because the smaller companies will always be keen to join the collaborative program in order to find solutions for their problems. The smaller companies themselves have been using equipment and services provided by the four giants and are attracted in order to expand their capabilities in using this equipment to solve their business problems. For the smaller and medium companies there is thus a need to use and become more knowledgeable in the usage of this equipment, and for the giants there is a need to penetrate the market of these small and medium companies. By joining ACSys the giants gain more access to achieve those objectives and create a bigger market.

In the Information Mixing Pot some problems related with information transaction, such as clear agreement about what the customers want and interpretation of the specific demand from different domains, are discussed and solved. The Information Mixing Pot also functions as a formal selection mechanism for all information flows and is the place where the de-codification and re-codification of information takes place. Thus the Information Mixing Pot is a place where the information is collected and is used to select and to determine new projects in the future (allowing for better planning). This Information Mixing Pot is working in continuity in the course of the program (the boxes within the ellipse are working in continuity). The successful innovation is offering the market something new for which the customer is prepared to pay. This arises from new technology or a new application of existing technology.

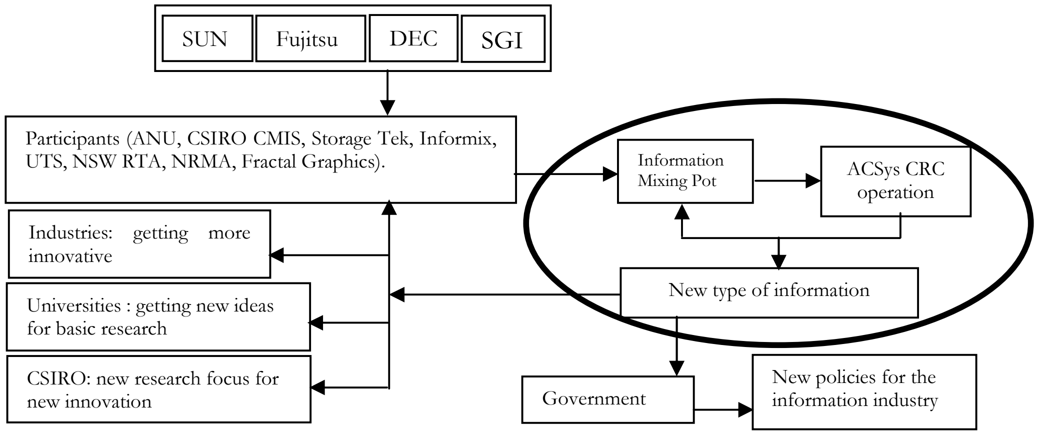

Figure 8.3. The operation of the ACSys CRC from information flow perspective. Source: Author.

The results of the process[55] is fed back to the Information Mixing Pot and can be used as a new reference for the new method of running the entire ACSys CRC. The mixture of the evaluation results and the other types of information are a new type of information. Again this strengthens the argument that the giants are keeping every bit of information activity under their codified format. This information is fed back to the participants and also informs the government. The government can use it for accountability for the ACSys CRC grant and to help in drafting new policies in the information industries.

The Newt model suggests that the type of information being transacted determines the method of codified process in transferring that type of information. Each participant has contributed different types of information. However the process of transaction of this information must be conducted in a single codification. Thus, there is a need to have a translation regime which allows the process of de-codification and re-codification of the type of information submitted by each participant. The Newt model suggests that in such a process of translation there will be a special role played by a special participant. This relationship among the participants is a direct implication of the process of information transaction from the Newt model. Moreover, as the Newt model suggests, the role of the Internet information system is also quite important in the process of translating the codification from/of each participant. The following figure 8.4 pictures the position of the ACSys CRC as a translation regime in the web of collaboration among the participants from industry, university and PSR.

Please see print copy for Figure 8.4

Figure 8.4. The position of the ACSys CRC as a translation regime among participants of a collaborative research partnership. Each ellipse represents codification used in communication exchange within each organization. Source: Author modified from Leydessdorff (1997)

The industries (figure 8.4) consist of the giants and some other smaller companies. The smaller companies are all users of products and services provided by the giants. In figure 8.4, the PSR is CMIS (and later also Defence Science and Technology Organization, DSTO) and the university is ANU (and later University Technology of Sydney, UTS). The ellipse with the dashed line pictures the position of the ACSys CRC as a translation regime.

The following paragraph demonstrates that the operation of this translation regime is basically controlled by the giants. As described in previous sections, the giant's main interest is any type of information which is useful for the expansion of their markets in Australia.

Given that in this CRC there are many types of information being exchanged, the information transactions used are also varied. Moreover the participants are from different types of organizations making for a completely different method of information transaction.

[55] This process consists of formal selection mechanisms of several types of information from the participants and the codification and de-

This kind of situation creates a need to have many dynamics (of information transaction) for each participant. To bridge the traffic of information from one participant to another will be the main task of a translation regime. Beside the codification of information transaction, which is introduced by the giants, the government has the capacity to impose a similar codification in the ACSys CRC. The government is the major funding provider for this CRC. This funding can be used as a kind of method of codification in the dynamics of information transaction within this collaboration. The method for achieving this is by asking all ACSys CRC participants to write down a formal report for the CRC secretariat regularly, financial reporting quarterly and performance reporting annually, as part of its accountability. In this way the codification of information transaction used in the collaboration can be evaluated by government.

As noted, the main interest of the smaller companies in joining this collaboration is to solve their technical problems by using technologies provided by the giants. These companies exchange information which is relevant for this purpose and thus the codification used for transaction deals mainly with technical information. Meanwhile for the research providers such as CMIS and ANU the codifications used for information transaction deal with technological excellence especially in order to keep the Australian information industry at the leading edge of the technology throughout the world. Table 8.2 summarizes all codifications used by each participant in this CRC. It explains what the content of each ellipse pictured in figure 8.4 is. The main task of the ACSys CRC is to function as a translation regime between the different codifications (Table 8.2) of each participant so that participants can "speak" to each other. In practice, this task of translation is manifested by two main factors: (1) the

codification of the information.

ACSys CRC as a coordinating board and (2) the Executive Director of ACSys CRC, which have to function as the agent of translation. The ideal format of information transaction in this CRC is when the main type of information being exchanged (which determines the dynamics) comes from the industries (both giants and smaller companies). This type of information concerns about the technology required to solve industry's problems.

Table 8.2. The codifications used by each participant of the ACSys CRC.
Source: Author, from the interviews.

Organization	Type of codified information	Used codification for Information transaction within ACSys CRC
Giants/Large Companies (Fujitsu, Sun, SGI, and DEC)	Market and Related Marketing Information for their benefit.	Formal business oriented information transaction, through regular meetings, with a very strong competitive accent between Fujitsu and Sun.
Smaller Companies	Technology Information for Business Problem Solving.	Formal business oriented information transaction, through regular meetings, with no competitive attitude.
Government (CRC Secretariat)	Funding Allocation, performance indicators and success stories.	Formal information transaction, non competitive, through a written report in a very codified format every three months
Research Providers (PSR and University)	Technology Information for Leading Edge and Capturing the Technological Excellence.	Formal business oriented information transaction, through regular meetings, with no competitive attitude.

The research providers (especially CMIS and ANU) are supposed to provide the required technical solution for these problems. For the research providers the process of solving the industry's technical problems will provide them with access to industry's needs. This kind of information (the industry's needs) may open new dimensions for CMIS and ANU researches, for ANU as an education institution this can also be used to increase the teaching quality. As noted, to achieve all these objectives, it is the task of the ACSys CRC to translate the different codification from one participant to the others. However, in this CRC, the giants are the only ones which possess nearly all types of information for solving the problems of the other participants. The giants also master all types of information which are supposed to be delivered by research providers. The giants with their higher reputations in the information industry do not need any kind of technological type of information related to technological excellence even from the research provider. The giants have a much higher information capacity compared to other participants in this CRC.

The asymmetry in this information capacity determines the codification given that the type of information being exchanged determines the method of information transaction used. Thus the giants are also mastering the codification of all kind of information. The translation process consists mainly of the de-codification and re-codification of codified information, but, given that the giants are suppliers of this knowledge, products, and services in the ACSys CRC, they are in a position to control the process of translation of codification for the transaction of information. This is because the giants limit all possible information transactions which are outside their interests. To conduct this task is easy for the giants, given all software and hardware are supplied by them, not to mention all spare parts, accessories and services and all associated information required to operate this hardware and software.

In this translation process, it is the giants which drive the process so that it is always within their interest and always produces results, which gives direct profits to them. Thus every kind of translation process is driven as such to make it convergent to market information required by the giants. As the Newt model suggests, a kind of agreed CRC's style codification must be created during the process of de-codification and re-codification. This

CRC's style codification is supposed to 'move' to all participants and translates the sub-dynamics in each participant, and selects the best among them which can 'understand' other's codification. This CRC's style codification must be working for the master.

The giants are in the information industry business, so the codification that they are using for information transaction is limited to industry business matters (especially for marketing). The nature of the translation regime enables it to move from one participant to others and then within each participant trying to translate the codification used in that particular participant. When it moves to another participant it will translate it in that participant by taking all the codifications used in that participant. In the process of translating the codification, the translation regime can also select the best available dynamics within each participant which can be used to help translate the codification of the information transaction. This process of selection should be under the control of the translation regime and not under the control of any of the dynamics or the "genotype", which is being selected by the regime.

However in the ACSys CRC such a phenomenon has happened. The dynamics within the giants' entity, which are supposed to be one of the genotypes being selected, is in a position to challenge the selection mechanism itself and proposes a different selection mechanism. This problem exists because these giants are in a horizontal competition. This creates another kind of selection mechanism, besides the mechanism provided by translation regime. This new selection mechanism is challenging the CRC's function as a translation regime. The spider diagram in figure 8.5 is developed as an extension to the figure 8.4 to give a better visualization to the operation of the translation regime. However, due to another strong opposing force challenging the 'proper' translation regime, our spider will have more than one 'body'.

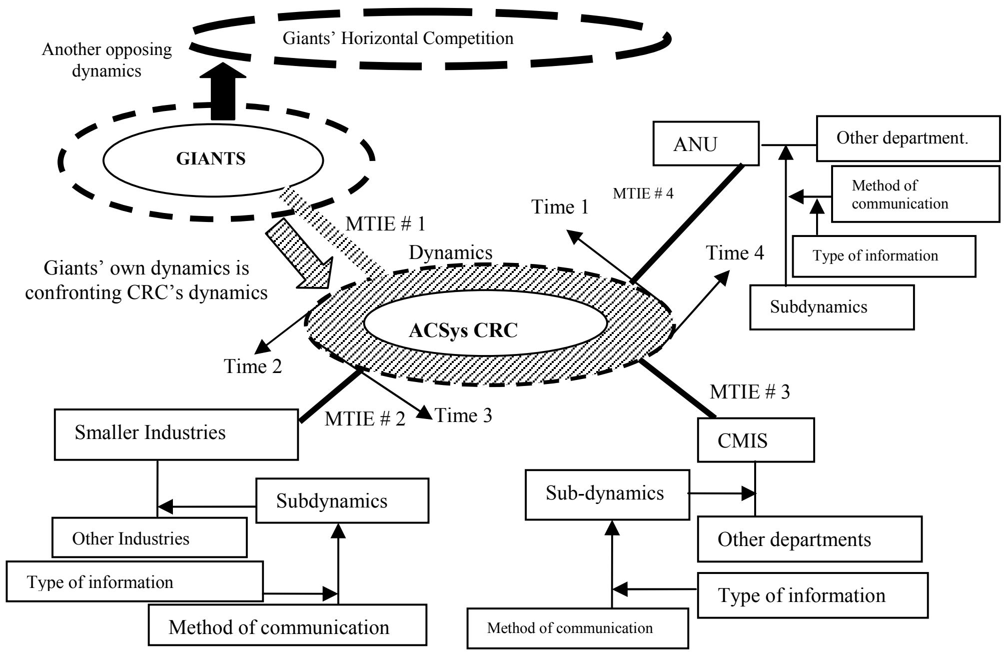

Figure 8.5. The position of ACSys CRC among sub systems and sub dynamics of its members. Note: MTIE: Main Type of Information being Exchanged. Source: Author.

This (quasi) spider-diagram in figure 8.5 gives the position of the ACSys CRC as a translation regime for translating the codification used (see table 8.2) to each participant in the collaboration. The name quasi is used since our spider no longer has one "body" with several equal "legs". There is another body (in the upper left of figure 8.5), so there is a "leg" which has become a "body" of the spider. The reason is because the ACSys CRC as a translation regime has to confront another major dynamic, this is from the giants' dynamics, which is caused by horizontal competition among the giants themselves (DEC, Sun and Fujitsu). However the remaining three legs from the University participant (ANU), PSR (CMIS) and other smaller companies also have their own sub-dynamics. These sub-dynamics are caused by a different type of information being exchanged which requires a different type of information transaction. This happens because, during the course of collaboration, each participant may exchange information with others (CMIS may exchange information with other departments at the CSIRO and the ANU may exchange information with another universities etc.).

Similar to the role of the two previous CRCs, this CRC as a translation regime will start moving at Time 1 to the first participant which in figure 8.5 is one of the giants. The MTIE # 1 is market information and user's needs in Australia for this giants' benefits (table 8.2). In fact to understand the dynamics and sub-dynamics in this giant is already problematic for the ACSys CRC. The reason is because there are strong opposing dynamics within this participant. This is from the giants' own dynamics. These dynamics are opposing, because they attempt to codify the entire system of codification in the entire collaboration. Thus, the process of de-codification and re-codification for the type of information cannot be executed properly, owing to the existence of this opposing 'force'. These opposing dynamics are caused by horizontal competition between DEC, Sun and Fujitsu. The process of translating the MTIE # 1 is thus problematic for the ACSys CRC. This is shown by the dashed line (which is connecting the body of the spider in the middle, to the second body of the spider). Thus, in the MTIE # 1 there are challenging dynamics to control the process of de-codification and re-codification against the 'proper' CRC translation regime (ellipse with dashed line at the centre of the quasi-spider diagram). Thus at Times 2, 3 and 4 the CRC can no longer function as a proper translation regime to help in translating the codification from participants to participants (MTIEs # 2, 3 and 4) because it has already been 'contaminated' by the MTIE # 1. The translation regime, however, cannot start from either Time 2, 3 or 4, because the giants are dominant participants in this CRC. The process of translation of codification is determined fully by the MTIE # 1 which, thus means that it is fully influenced by the giants. This is symbolized by the dashed line in the ellipse at the "body" of this quasi-spider diagram (the spider's main body). Thus the MTIEs # 2, 3 and 4 will be no longer the MTIEs # 2, 3 and 4 as supposedly listed by table 8.3, but contains with some elements from the MTIE # 1.

Thus, in this CRC there is another 'force' which is playing an opposite role. This is the 'force' caused by the dynamics from the horizontal competition between giants (symbolized by the third ellipse with different dashed line at the top). Even the nature of the MTIE # 1 is thus no longer a pure MTIE from the giants, but a complex mixture of market competition among the giants themselves. Therefore, in this ACSys CRC there is no *real* master, given that the giants themselves are in horizontal competition. Thus, in the ACSys CRC the translation regime cannot function properly, because the selection mechanism of the regime cannot be achieved by the translation regime itself. The selection is already contaminated by the codification from the giants.

It can be seen that in this case the translation regime cannot work properly when a large quantity of information and that part of information which is critical to the core of the collaboration is dominated by a particular entity (or group of participants) but this entity is in a problematic situation in the process of the information transaction.

The Internet has been used very extensively including to conduct the research itself. However, the Internet cannot have a useful contribution to the support of the translation regime by helping the Director as a translation agent in doing his/her job in this CRC. The main reason is simply that this technology itself is part of the codification, which is fully controlled by the giants. Sun for example controls all software and hardware and also all related products and services in the Internet. Fujitsu has the same capacity. Sun and Fujitsu are both giants in Internet technology but at the same time these two giants are in direct, horizontal competition.

The Internet thus has contributed to the process of total codification (of information transaction) of the entire CRC by the giants. In spite of the failure of the ACSys CRC to play a role as a proper translation regime, this case study has proven that the type of information and its process of transaction can determine the operation of a CRC collaboration.

8.4. AN ASSESSMENT OF THE 'NEWT' MODEL IN THE ACSys CRC

This section assesses the Newt model in the ACSys CRC. From the previous discussion it can be concluded that there is an asymmetry in the information capacity between participants involved in this collaboration.

In fact in the ACSys CRC there are many masters. These, which are called giants in computer and Internet technology, are: Fujitsu, Sun, SGI and DEC respectively. These four are the most important players in this CRC. These partners master the collaboration by determining the entire codification which is used for information transaction in the collaboration. The task of the CRC is supposedly to translate this codification to the entire participants so that these participants (the slaves) can "understand" the master's "commands". These masters make sure that the process of de-codification and re-codification which is being conducted is under their complete rule. These masters make sure that everything is conducted according to their codification so that these four masters will accrue the most benefit from the collaborative research partnership.

The existence of the master to slave relationship and the task of the CRC as the translation regime for the master are key features of the Newt model. The master normally controls the entire collaboration by submitting the main type of information, which becomes the main issue for the collaboration, and tries to codify all transactions of this information. In this particular example the main objective of the masters is to expand their markets. Thus, all the projects conducted within this collaborative partnership are completely ruled and well codified by the master in order to strengthen the masters' market position and to expand it. To achieve this, the masters have successfully utilized the ACSys CRC. The ANU and CMIS which were supposed to play a role as research providers for the collaboration have also become a codified part of the master. The masters need to expand the collaboration by getting more participants in order to include as many dynamics as possible within their codification because by getting more participants for this CRC the master can train the users and future users to become the procurers of their products. Executing such a task, for the four masters (the giants) is particularly easy. This is because all equipment, both hardware and software, are produced by them. Thus, this puts the possible types of new information being created (and its codification) under the complete control of the giant's codified system. The usage of this system with all technical problems is under the complete control of these masters. Moreover, the main important feature for the translation regime to function properly is to be supported by the Internet, which can enhance the process of information transaction among others within the web of collaboration. Such technology in this field is fully controlled by the masters, in fact this technology is part of the master's codification.

Thus, these four masters rule the entire transaction of information activities within the web of collaboration.

This creates a situation where the function of the ACSys CRC as the translation regime is fully controlled by the masters. The masters have codified the ACSys CRC as an instrument to gain another type of information that supports the sale of their products for their own benefit rather than as a research partner. For the Newt model this can be seen as a condition where the objective of the collaborative research partnership is totally driven by the masters. Thus the masters have been successful in recruiting the research providers as part of their market codification. It means that the masters do not want to utilize the ANU and the CMIS as their partners for doing research. The following example illustrates the situation[56].

In the project which deals with graphic design, all the software in this project are products produced by SGI. Given that SGI produces both hardware and software for this project, it is thus SGI which is in a position to determine the codification. The same situation applies to the two other important types of information within the collaborative partnership, these are information related to the internet technology and information related to the hardware technology.

All equipment for Internet technology is produced by Sun and Fujitsu. These two are giants in Internet technology. For these two giants there is no way that other participants may be able to control all information related to this kind of technology. Therefore the codification for the project which has a relationship to the application of this technology is dependent on

[56] Interview with Mr.Peter Milne, Program Leader for Data Mining Project, CMIS, November 9, 1999.

these two giants. These two giants are basically using the users in the ACSys CRC in order to translate the codification of the users so that they can better understand the users' need, in order to gain more benefits for themselves.

DEC produces the hardware equipment for the collaborative research partnership. The same thus applies because this participant (DEC) as the master will never share the information and give it to the other participants (the slaves). The codification which is developed is thus fully under their controls. Thus, the Australian participants and other participants only function as slaves of these codifications. They are part of the entity which is codified by the giants and this produces many limitations in the mixing of information to produce new types of information which may produce an innovation. Even if innovation can be created it is mostly accrued by the masters. To further limit access to types of information which are critical to the web of collaboration, the masters conduct their own research in their own country, making it nearly impossible for the ACSys CRC to function properly as a translation regime which can give equal benefit for the entire participants of the collaboration.

Meanwhile the ACSys CRC is supposed to function as the translation regime to translate the codification of information transaction from the master to the slaves of the collaborative research partnership. This function however cannot be fulfilled properly. The reason is because there are three competitors within the masters themselves. So this creates problems in using this CRC as a true translation regime. This CRC has been under the control of giants. However, in this position, the giants themselves are in horizontal conflict. The existence of this horizontal competition among masters adds other dynamics. The competition among these dynamics at the same time causes a situation where actually there is no master at all. This makes the function of the ACSys CRC as a translation regime in reflexively translating the codification of information transaction among participants much less efficient.

The collaborative research partnership of the ACSys CRC closed in 2000 after its seven years of operation. The Australian participants decided to put an end to this very complicated information transaction activity. While, at the beginning, the PSR, the universities and other participants expected that through the ACSys CRC a kind of platform to understand the giant's codification could be created and these Australian participants expected to get more types of information in terms of technological excellence and related aspects. However with such a complex situation caused by the horizontal competition among the giants, it was impossible to realize a proper translation function for the CRC. In this CRC there was a situation where there were different masters but they were interested in the same particular information. Thus each of the masters attempted to codify the process of its transaction under each master's codification and then each master attempted to impose their own codification on the entire CRC. This was a particular problem in this ACSys CRC for having more than one master and yet some of them were in horizontal competition. The following Table 8.3 summarizes the assessment of the Newt model on this CRC. In this CRC the Newt model has been applied to explain the process of information transaction and the role of the Internet information system. However, in this case study there are four very strong participants which all have the capacity to become the master and some of them are in horizontal competition. This condition has caused problems, because the Newt model suggests that in order to be successful a CRC must only have one master.

Table 8.3. (I). The Newt model applied to the ACSys CRC (continued on next page). Source: Author.

Theories from the Newt model	The process of information transaction in the operation of ACSys CRC	Comments
The operation of a CRC is an arena of information transaction. It must be triggered by a particular type of information and the operation must be based on this particular type of information.	Yes	This CRC has been established according to the main issue to conduct research related to information technology in computation, data base and graphics applications. The program has been drawn based on that particular type of information.
Each participant is assumed to have its own information with its own codification, while the transaction process requires a transfer of information from one participant to others. In such case there is a need for a translation media, this is called a translation regime.	Yes	The research providers provide particular information and maintain their codification of information transaction, such as requiring a part of the basic research activity prior to jumping to the applied activity. The industries put their representatives in each part of the projects. The Board of Directors provide as catalyst to convey all those differences. However the codification of the type of information provided by nearly all participants has already some contents of the giant's codification including the competition among them.
The process of information transaction is thus dependent on the role of the translation regime. The translation regime is dependent on a particular participant.	No	The translation regime in this CRC cannot work properly. It is under the control of many masters and these are in horizontal competition.
The process of information transaction is codification of information from each participant to CRC's codification and participants exchange the information to the other participant through an information channel which is also under CRC codification. This process must happen reflexively.	No	The spider diagram has shown (based on example) that another "leg" has become the "body" of the spider. The spider is basically no longer a spider but a "quasi" spider. This is caused by the existence of other different and conflicting dynamics.
This has an implication for the relationship among participants in the CRC. The participant which submits this particular type of information may have a special role. The relationship among participant is a master to slave relationship.	No	In terms of the master to slave relationship, there are four masters here. Some of them are in horizontal competition. Thus in fact there is no real master in this CRC, therefore there is no master to slave relationship.
The information system may contribute to support the process of information transaction.	Yes	The Internet as a computer based information system has played an interesting dual role in this CRC. It contributes to enhance the process of information transaction, in many cases this has been used as a method to conduct the research itself.

Table 8.3. (II). The Newt model applied to ACSys CRC. Source : Author

Theories from Newt model	The process of information transaction in the operation of ACSys CRC	Comments
The information system may support the master to "rule" the other participants.	No	On the contrary, the Internet contributes to "distribute" the conflict between the masters to the entire collaboration given the real ACSys's style of information transaction codification has never been able to be created in this CRC.

However, for the Newt model, this case study has strengthened the argument that the type of information being transacted may determine the success or failure of the CRC collaboration. The particular type of information in this case study have proven to be very critical in this collaboration. These types of information are fully controlled by the masters but at the same time they are the main interest for them. Thus, the masters control, and rule the information activities of these types of information but at the same time they are in horizontal competition with themselves, which involve these same types of information. This has caused the ACSys CRC to no longer function as a good single master controlled translation regime, and has brought to an end of the entire collaboration.

8.5. CONCLUSIONS

This chapter has presented the application of the Newt model in the ACSys CRC. This is a CRC which is dealing with the solution of the problems and seeking for technological excellence in the information industry. The analysis of this CRC has been developed by using the Newt model. From this Newt model this ACSys CRC is an interesting example, for there are four world class, very influential and powerful information companies joining the collaborative research partnership side by side with Australian smaller companies and (relatively less capable) Australian research providers.

Again, this chapter has shown that there is a particular type of information, which drives the establishment of the collaborative research partnership. Furthermore this chapter has again demonstrated that there is a certain mechanism of information transaction which is critical and determines the entire collaborative research partnership. However there is a big difference, between the type of information being pursued by the participants especially between the research providers and large companies (the giants). Moreover there is an asymmetry in information capacity among participants in this case study which then triggers a master to slave relationship as suggested by the Newt model.

The first main type of information remains technical information dealing with solving problems in the information industries. It is this type of information which triggers the participants of various sizes to join the collaboration. All participants who pursue this first type of information are from research providers and industries. The second most important type of information is related to the giants' interest, this is the market information especially about the need to expand to the Australian market for the industry's products and services. From the Newt model, the operation of this ACSys CRC is similar to the other two previous CRCs, where the operation for information transaction is based on formal meetings. The Internet information system has been deployed to enhance the quality of the mode of information transaction in the meetings. As has been suggested by the Newt model, this chapter contends that the participant which has the largest information repository drives and masters the entire collaborative research arrangement. In this CRC, the giants master the bulk of information being processed and thus limit the exploration of information for the benefit of others especially for the research providers. By controlling nearly all kinds of information the 'giants' have been able to control the mechanism of information transaction, moreover they also control the dynamics of the information transaction process. The giants also use this capacity to rule and drive the activities of the entire collaborative research partnership and have used these activities as a kind of arena to get a new mixture of information only for their benefit.

The chapter has concluded that the giants' preferred information has become the main driver of the entire collaboration and allows the giants to get the most benefit from it. Thus, the focus and the objectives are completely dependent on the direction governed by the participant with the largest information repository. Therefore the entire process of information transaction in this collaborative research partnership has been driven by a group of very strong participants, in terms of information capacity, so that it converges to certain types of information. In this example it is to market orientation in order to give the giants better access to providing service and products to their market in Australia. Moreover this chapter also concludes that the giants attempt to put their objective as such so that it becomes the main objective of the entire collaborative research partnership. This is done by forcefully putting all the participants within the collaboration under their codification of information transactions. Thus in this CRC, there is a strong tendency for the diversion of types of information by very strong and influential participants. In the course of the program the ACSys CRC has become part of this strong participant's codified system of information transaction. This chapter contends that the process of such a diversion for the type of information being exchanged dominates the operation of the collaborative research network.

It has shown that finally the giants are able to achieve their objective by controlling this diversion process, for they master a larger information capacity than the smaller industries including less capable Australian research providers.

The chapter has presented the argument that the ACSys CRC cannot function properly as a translation regime because of the existence of other "regimes" which are confronting against the CRC's translation regime. This different (but opposing) regime is caused by the direct competition among giants themselves. It has been found that because of this situation the CRC's translation regime is unable to function properly. This fact has caused the conclusion of this ACSys CRC after its first seven year period. This time, the CRC's operation has failed, for there are many strong participants in horizontal competition. Thus there is no genuine master to slave relationship. This chapter has presented that a true master to slave relationship is the key for a successful CRC, when there is no such relationship a CRC collaboration will cease.

CHAPTER 9: A COMPARATIVE ANALYSIS OF THE THREE CRC CASE STUDIES

This chapter presents a comparative analysis of the three CRC case studies. The Newt model developed in chapter 5 will be compared in its applicability and its suitability in each CRC case study. It will also be assessed to what extent this model works in explaining the process of information transaction and the role of the information system at the CRC.

From previous discussions in chapters 6, 7 and 8 it has been found that in these three CRCs there was a particular type of information (combined with its transaction mechanism) that contributed to the success (or failure) of a CRC's operation. From the previous chapters it has also been found that the three CRC case studies have completely different features. A remarkable feature is that one CRC (ACSys CRC) had closed down while the other two CRCs (CRC WS and CRC QW) were quite successful in their operations. One of them (CRC WS) had managed to continue to the next seven years round of operation and had undergone an evolution given many fundamental changes had taken place in this CRC. The other (CRC QW) was running well in its operation. From the previous chapters the thesis had described that the process of de-codification and re-codification of a particular type of information contributed to both successes and failure of a CRC. In this chapter, the Newt model is further explored especially in regard as to how this model can explain in more detail the importance of the information system in the operation of a CRC by comparing the three CRC case studies. These analyses, later lead to some policy implications in section 10.2

The organization of this chapter is as follows: Section 9.1 presents a comparative analysis of the three CRC case studies. The critical elements of each CRC will be articulated and discussed from an information perspective. Section 9.2 provides an analysis of the Newt model and its applicability to the CRC. Finally section 9.3 concludes that a critical feature of information transaction is the relationship between the information "capacity" of different participants that leads to an understanding of the importance of identifying the information "capacity" of each participant in the CRC.

9.1. THE GENERAL FEATURES OF THE THREE CRC CASE STUDIES

The objective of this section is to identify some general features of the Newt model from the previous three CRC case studies which will be used in the comparison between the Newt-style CRC and the actual CRC in section 9.2.

In all three surveyed CRCs, the main type of information being exchanged is similar, that is the technical type of information used to solve particular technical problems. In the CRC QW the main type of information being exchanged among participants is technical information about the development of a new wheat variety. In the CRC WS the typical type of technical information being exchanged is about welding-time, and in the ACSys CRC the typical type of technical information is about software development related types of information. The participants within these CRCs also started with the collaboration in order to exchange technical answers for their technical problems.

The mechanism of information exchange and the type of information being exchanged are the two determinants of the process of information transaction within all three CRC case studies. The mechanism of information transaction is using a standardized system. All three CRCs have an integrated information system as a vehicle for enabling fast information exchange. Furthermore some conventional methods such as meetings between participants of the collaboration program are also used as a standard method for information exchange. The participants in these three CRCs have a different background, which determines how they transact the information. This determines their method of communication (in the process of information transaction) and thus determines the codification of the information transaction. From the previous case studies, it has been found that there is a tendency for information to flow from the participants with the largest capacity in a particular type of information to the participant, which has less capacity for this particular type of information. The participants with the largest capacity of information are likely to trigger and to control the transaction of information. The participant with the largest capacity of information is the most important component in the collaboration and this participant is called the 'master'.

In the ACSys CRC the operation ceased after a seven-year period. The reason was because the master (the 'giants') had no capability to create such an environment where there would be a participant which had a larger capacity of information and there were other participants with less capacity for information so that information could flow from one to another. In the ACSys CRC the giants were in competition themselves, so that such a large 'information bucket' could not be created. A true master to slave relationship thus could never be created in this CRC.

In the CRC WS and CRC QW the situations were different. The CRC WS had BHP, which could maintain a master to slave relationship. The same applies to the CRC QW, with the GRDC as the creator of the 'information bucket'. It must be noted that the master to slave relationship remained dominant. Thus, the aim was not to allow the 'information bucket' of the masters become empty and let the other participants (the slaves) get all the information from the master. Rather, the information transaction process had to be designed so that the 'information bucket' of the master would never be empty. On the contrary it would increase in terms of its volume, by getting a newly created type of information after transferring some of its content to the other participants (the slaves). This was the process which was strongly well codified by the master.

In fact, there was an increase of information capacity among participants within the ACSys CRC. However the level of increment was much less than that within the CRC WS and the CRC QW. When such an 'information bucket' has been created, the next important consideration in the CRC is to establish a channel so that the information can flow from the master's 'information bucket' to other participants (the slaves). Such an information channel is normally realized in a very formal way, which again reveals the need for a strong codification from the masters (to make sure that they can exercise their mastership).

In the ACSys CRC the same concept of information transaction applies. This CRC has four multinational companies. The main objective of this CRC is to increase the information capacity of the participants of the web of collaboration. However, these big companies use this process of increasing the information capacity program in order to open new markets for their technology products. These big companies without a doubt never used the ACSys

CRC as a kind of centre for their technology innovation research. These big companies have their technology innovation research facilities and departments in their home countries. Thus their 'information bucket' is located somewhere overseas and they use their Australian counterparts only as a method to increase the content of their bucket in their home countries. From this perspective the relationship between these two kinds of research agencies is also like a master to slave relationship. The research agenda is totally directed by the research agencies from these four big companies (which is based purely on their marketing plan). The level of innovation being conducted through this ACSys CRC for Australian research facilities and Australian industries remains under the control and direction of these big companies.

However, the problem in this CRC is that these four big companies are in a rival situation. Thus there is a kind of strong imbalance situation in regard to the information transaction from the master's 'information bucket' to the slave's 'information bucket'. These big companies are using the CRC as a kind of place where they can introduce their products to be used as the sole device for solving problems and strengthening their market position against others. This creates a condition where the new information being produced and being exchanged within the web of collaboration becomes part of their competition. The slaves in the ACSys CRC cannot develop any kind of new information beyond their competition. Basically, a similar situation also happened with the other two CRCs, where the master always tried to 'reign in' all the slaves under its codification. However in the ACSys CRC such a situation could never be created because the process of creating a codification under a true master to slave relationship is impossible for there is a strong competition among the masters themselves.

In the three CRC case studies, the master exercises its master's position based on research being conducted. The main activity in this information transaction is doing research. Thus the creation of a new type of information or mixing several types of information can be conducted through this research. The main objective of the exploratory research mode at the CRC is to solve technical problems within Australian industry. Each participant (mostly from industry) within the CRC may have a different research mode in doing R & D activity. Thus, in the three CRCs, there are various activities in the doing of research among participants. Small-scale companies from industry in the CRC normally conduct no research at all. However, some big companies, especially multinational companies, may conduct exploitative and/or an explorative mode. Thus the level of excellence in doing research of participants in the CRC varies. This creates a different capability in the creating of a new type of information, which again, strengthens the position of the master to exercise its mastership especially in the process of mixing the information (in order to find the solution to problems). The master furthermore codifies the process of information transaction, making it no longer possible for the slaves to create a new kind of information. Therefore within the Information Mixing Pot, at each CRC, there is a mixture of the type of research modes being conducted. However the interaction between these research modes can increase the master position.

When it is no longer possible to maintain a master to slave relationship to solve technical problems it is likely that the collaborative research program may cease. In the ACSys CRC this phenomenon has happened.

9.1.1. THE 'INFORMATION MIXING POT' IN THE THREE SURVEYED CRC

In the previous three case studies it has been explained that the real place where the process of information transaction is happening is called the 'Information Mixing Pot' (see Chapter 5 section 5.4).

As noted earlier in Chapter 5 section 5.4, the existence of an 'Information Mixing Pot' creates a situation where the slaves have to change their codification (in the process of the information transaction) in order to enable better interaction with others in the information transaction, which is controlled by the master. However for the three CRC case studies the alternation of codification is only between two kinds of codification, namely science and economy (see figure 9.1). Each participant in the three CRCs becomes an institution between these two codifications. Only when they can adapt themselves to operate in this kind of situation can they survive to become a participant of the CRC, otherwise they have to quit the CRC collaboration. Under such an institution the interaction happens, and from an information perspective, this allows a mixing of incoming information with all types of information in the 'Information Mixing Pot'. Sustained capability in dealing with this adaptation is a 'must' in order to remain as a participant in the CRC collaboration.

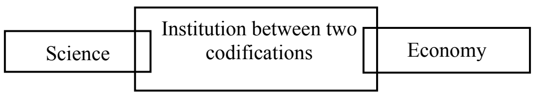

Figure 9.1. The establishment of a new institution between two different codifications.
Source: Author

The mixing of information is conducted within the institution between these two codifications and this provides resources and feedback for both codified systems. In the

'Information Mixing Pot' the operation of the information transaction as described above is conducted under a condition where each participant is supposed to operate reflexively between two codifications in figure 9.1. For the Newt model, only in this mode can the CRC work properly, because, in the 'Information Mixing Pot', information, which is coming from various sources (various codified systems) has to be selected and processed in order to, for the three surveyed CRCs, mainly solve industrial problems or create innovation.

9.1.2. THE ROLE OF THE INTERNET IN CRC INFORMATION SYSTEMS

In general, the existence of the Internet information system has been used to support the process of information transaction, however the Internet can also further strengthen the mastership role of the master in dominating the entire collaboration.

In these three CRC's the Internet has enhanced the process of information transaction among participants. The research conducted requires high-speed information exchange, because it is high technology activities while the participants are mostly separated by distance. The Internet allows for a quick and comprehensive information exchange. The usage of the Internet is increased, first of all only as a communication media using electronic mail and then it is expanded to become a marketing media (through a website) and expanded more for sending some important documents until it becomes integrated as a system for doing research.

In both the CRC QW and the CRC WS there is a comprehensive Internet-based information system to enhance the effectiveness of the communication process. Both CRCs consider that a strong and powerful communication systems can enhance the process of information transaction, which in turn increases the performance of the entire collaborative research. Both CRCs have developed their own Internet based integrated information systems in order to anticipate the required speed of the information transaction in the web of collaboration. Using this information system allows them to monitor and to access all the required information transactions starting from the project inception to the project completion. The participants of both CRCs have built their web pages on the Internet, and they have been using this facility for direct communication with all other participants. The problems being researched in both CRCs are not directly related to the Internet. However the development of the Internet has enabled both CRCs to utilize the Internet quite significantly. For example the ability to do calculations from remote areas using the Internet has enhanced the speed of research work among participants of research collaboration the CRC WS. This has allowed the CRC WS to integrate the Internet to develop an Internet based information system called IPMIS.

In parallel to the two previous CRCs, the ACSys CRC also uses the Internet information system for enhancing the process of information transaction. For example SGI is using the Internet as a media to exchange research results during the course of the program. In fact, the application of Internet usage is at its most extensive in the ACSys CRC. The main issues within this ACSys CRC are directly Internet connected such as computer program development, database development and graphics development. This is especially so far the database development where all the data set from different parts of the sites (of the ACSys participants) can be directly connected and integrated, so that the users and producers of the knowledge can directly interact with each other and exchange all required research information leading to problem solving and innovation. The same applies to graphics applications (also within the ACSys CRC). The advent of the Internet has enhanced the ease of exchanging information about this type of technology more than ever. The graphics can be sent directly via the Internet and from the users and producers of this particular information so that there will be an increase of step of information exchange. Thus from this perspective, the level of usage of the Internet is higher in the ACSys CRC compared to the other two CRCs. The next section 9.2 explains how the Internet plays an interesting role in this particular CRC.

9.2. A COMPARISON OF THE "NEWT STYLE" CRC AND THE CRC CASE STUDIES

This section describes the Newt model and its suitability for the three CRC case studies. In particular it asks to what extent this model works for the CRC. The discussion in this section will lead to some policy implications, which will be introduced later in section 10.2.

Table 9.1 compares the findings from the field survey with the main features of the Newt model introduced in chapter 5. The emphasis of Table 9.1 is as a starting point to the discussion about how the Newt model has worked in each of the CRCs under consideration. Table 9.1 suggests that when one of the features of the Newt model is not fulfilled then the CRC collaboration will cease. Thus from this perspective the Newt model suggests that there are some requirements for a successful operation of a CRC.

Table 9.1. The suitability of the Newt Model for assessing CRC operation. Source: Author.

	CRC QW	**CRC WS**	**ACSysCRC**
Feature 1. There is an asymmetry in the information capacity among participants, which will create a master to slave relationship.	Yes	Yes	No
Feature 2. CRC can function as a translation regime.	Yes	Yes	No
Feature 3. CRC is functioning as a translation regime for One Master only.	Yes	Yes	No
Feature 4. The Internet based information system has contributed to create and strengthen the master to slave relationship.	Yes	Yes	Yes
Conclusion: Is the surveyed CRC successful?	**Yes**	**Yes**	**No**

The first feature of the Newt model suggests that there must be a **master to slave** relationship in the CRC in order to guarantee a successful CRC operation. *Thus, without a true master to slave relationship the Newt Model states that the CRC may not work*. This applies either when there is more than one master or when there is no master at all.

Given that it is possible to create a new type of information by mixing it with another type of information, the Newt model states that it is the intention of the master to improve the capacity of that particular type of information (both its quality and quantity) which triggers the entire collaboration. It is thus the type of information delivered by the master which will become the main ingredient of the CRC collaboration. Thus the Newt model states that CRC collaboration is successful when the master can play such a role in the collaboration. When such a condition cannot be fulfilled, the CRC collaboration may be likely to cease. Based on the three surveyed CRCs this kind of condition happens when there are masters in horizontal competition, so that such a kind of asymmetry cannot be created because there is more than one participant claiming position as the master. The transaction of information (in terms of its capacity) from one master information bucket to others may never occur. On the contrary the conflict among masters (or the participants which have a large information capacity) may cause the information buckets to be of the same "volume", which would create no information transaction at all. And when there is no information transaction, there is no need to have a method of communication (for the information transaction) and thus there is no need to have a translation regime. The Newt model suggests that there must be only one master to guarantee a single codification in the process of information transaction.

The above described situation happened at the ACSys CRC where a true master to slave relationship never existed. In this CRC there were four 'giants', of which three were in direct and horizontal competition against each other, making it impossible to have one single master ruling the entire collaboration. Meanwhile in the other two CRCs (CRC WS and CRC QW), master to slave relationships were established. In the CRC QW the identifiable master was the GRDC, while in the CRC WS the master is BHP Steel Pty. Ltd, with two special slaves, WTIA and APIA. However BHP was still in a position to exercise its mastership even to WTIA and APIA. As the relationship among masters is important, it is concluded that the number of masters are also significant.

Moreover the Newt model suggests that in the course of the CRC collaboration program there must be a situation where asymmetry is maintained. This is required in order to guarantee that the CRC collaboration remains operational. In the CRC WS, BHP as master was successful in maintaining its position as master of the collaboration. This means that an asymmetry of information capacity could be maintained by BHP. In the second round BHP was again the trigger of the collaboration and until the end of the survey work the collaboration remained operational because the asymmetry in information capacity remained in favour of BHP. In the CRC QW, the GRDC was the master and the other participants were the slaves. The asymmetry in information capacity could be maintained by GRDC in the course of the program. For the Newt model, the ACSys CRC ceased because the conflicting situation among masters could never create a situation where there was an asymmetry of information capacity.

The Newt model further suggests that the master also wants to increase its information capacity in order to become a more dominant player in its particular field. The main intention is to remain in a position as master in its particular field. This can be achieved by mastering all types of information in this particular field. Thus by having a greater capacity of information the master is able to maintain its position as master and continues to 'enslave' the other participants. In the three CRCs these masters come from different background. In the CRC WS and CRC QW the masters are a large company and research investor respectively, while in the ACSys CRC there are multiple masters which are all large companies. Such masters will mobilize their slaves in the collaboration and attract more 'minor' participants (including universities, SME and PSR) to join the collaboration and to become slaves of the master. Using this method more information can be collected in order to improve the capacity for the type of information submitted by the master (which can be used for example to create radical innovation due to greater variation in its information collection).

For the Newt model, the more information that can be collected by the master, the more influence can be imposed on the slaves and this allows the master to control the entire information transaction in the CRC web of collaboration, making this master the key player and the determinant of the usage of such information transaction. This master-slave relationship in terms of information capacity means that this information transaction is driven and completely dependent on the master. In fact, from the previous discussion it has been found that the slaves become recipients or users of the new type of information being created by the master because only the master is the only participant which has full control of the information transaction within the web of collaboration. Again this situation strengthens the position of the master against the slaves.

In the three CRCs there was one similar type of information, which become the main issue for the master to trigger the collaboration. This most important type of information can be categorized as technical information (which is dependent on the type of CRC), particularly that which is closely related to the solution of the business and technical problems of the master organization. The slaves exchange the same type of information (technical information which leads to the solution of business problems). This type of information is also the main driver for the slaves to join the CRC program, with the expectation that the solution for the master organization is applicable to their own technical problems. From the survey it has also been found that the master (of the previous three CRCs under survey) was usually already a leader in the field of the technology being researched in the CRC program and consequently this master had the largest information capacity compared to other participants joining the collaboration.

The second feature of the Newt model suggests that the main role of the CRC is to function as a **translation regime**. As has been suggested, the important trigger for a CRC collaboration is the intention of the master to have an information transaction with the slaves but this process must be under the control of the master, in order to create a pure master to slave relationship. To execute this task there is a need to have a medium which translates the codification of the master to the slaves and vice versa. As noted such a medium is called a 'translation regime' and the Newt model suggests that the CRC itself has to operate as a translation regime. The mechanism whereby the master can control the information transaction through the CRC is by using the CRC as a translation regime for the codification of communication among the slaves when they submit their type of information. Moreover the CRC can be used as a translation regime for the same purpose in the process of translation of codification by using the type of information submitted by the master to become the reference for all slaves for further development of the new type of information.

For the Newt model, the information which is used to operate the collaboration is a mixture of information provided by the master and by the slaves which is referred to the type of information provided by the master. As explained earlier in section 5.4, in the Information Mixing Pot, this mixture of information is evaluated and the result is used as new input for the new mixture of information within the next cycle of information processing. The residues of this mixture of information can be used by the slaves for increasing their information capacity as for example to create limited innovation (limited compared to the master, given that the slaves always get less variation of information because the information processing is conducted under codification set by the master). Again for this last part, it is still within the control of the master by using the CRC. In practice the mechanism used for information transaction within the Information Mixing Pot is that of conducting formal meetings on a regular basis which emphasizes face to face contact.

From the surveys it has been found that the CRC can function as a translation regime for GRDC in the CRC QW, and as translation regime for BHP in the CRC WS. In the CRC WS, to a limited extent there was quite a strong role of two important participants in this CRC. These were WTIA and APIA. These two participants, mastered some types of information which were also important in the web of the CRC WS collaboration. Moreover these two participants played a role in the development of the type of information submitted by BHP to other types of information in a way that quite significant for BHP itself. However there is no direct competition between BHP and these industry consortiums participants and thus the opposing regime was non existent in this CRC, meaning the CRC WS can still function 'properly' as a translation regime solely for BHP. BHP also remains at the head of the codification process by using the BHP designed information transaction method through the Internet (this will be explained below).

However the CRC did not function properly as a translation regime in the ACSys CRC. As has been described before, the main function of the CRC as translation regime for participants is to translate the particular codification of method of communication from one participant to others. Obviously there is a need to have one kind of translation regime in this codification process so that it can be translated by this regime to other participants. Unfortunately, at this ACSys CRC, there were several participants that had a huge capacity of information, but given that these participants were in direct competition a real master to slave relationship could never be created.

Thus the translation regime which is supposed to translate the dynamics of information transaction from master to slaves could never function properly because there were multiple (translation) regimes in this ACSys CRC. In general, the CRC can never function as a translation regime when the codifications which have to be translated are not well defined. The study, by taking the three CRCs as examples reveals that one of the conditions which can create this situation is when participants with a large capacity for information are in conflicting horizontal competition. That is there is more than one strong participant which has the same interest in terms of the type of information which is going to be transacted among participants. This condition did not happen with the other two CRCs, because there were single dominant participants which were trying to codify the entire process of information transactions for their own benefit. This second feature strengthens the argument concerning the importance of the type of information in the collaboration. This feature may determine the success or failure of the collaboration. The second feature also strengthens the role of the type of information that determines the method of communication exchange from the master to slaves and also in the case of multiple masters, among the masters themselves.

<u>The third feature</u> is the strengthening of the second feature. The collaboration can operate successfully when there is only one master imposing its type of information on the other participants (the slaves). The process of doing this is by using the CRC as a translation regime to translate the codification from this one master to the other participants (the slaves). Thus there must be only one codification otherwise it would be difficult for the CRC to execute its task. The CRC must serve to this one master only and this means that there must be no powerful participants, in terms of information capacity, which stand face to face in horizontal competition. This horizontal competition among participants with a large capacity of information will create a conflict in the codification of method of used communication and will create further conflict in the process of information transaction. This is reasonable given that the method of communication is dependent on the type of information being exchanged, making this type of information impossible to be translated by the CRC to other participants in the web of collaboration. Such an environment is difficult to create, for another strong participant with more or less similar capacity in information will try to do the same thing. This will create an opposing dynamic in the process of information transaction.

The existence of opposing dynamics strengthens the importance of the particular type of information in this collaborative research environment. Moreover if these large organizations are in competition against each other there is then a conflicting situation in the process of flowing the information from master-bucket to slave-bucket since there is no clear identification as to which one plays the role as master and which as slaves. The so called dominant type of information, which drives the collaboration and is supposed to be under the control of the master and is supposed to be translated by the CRC to the slaves may never exist. As noted, the Newt model requires a situation where there is only one translation regime in the process of translation of the codification, which means that there must be only one method of communication used in the process. This requires that the main particular type of information being transacted must be under the full control of one master. When there are multiple masters in horizontal competition, there is always more than one kind of codification in the method of communication being generated due to the many types of transacted information coming from different masters.

In the surveyed CRCs it has been found that the ACSys CRC had been basically faced by such a problematic environment. In this CRC there were many masters trying to dominate and use this CRC as a translation regime for the codification of their own type of information to other participants. In the other two CRCs such a situation never existed. Both the other two CRCs worked well given that in each of these two CRCs, there was only one master using the CRC as its translation regime.

The fourth feature related to the way that all three CRCs have used the Internet as their information system. The Internet contributes to simplifying the process of information transaction. By so doing, the Internet was also effectively simplifying the process of codification of the type of information. In the CRCs under consideration, the Internet has been used extensively as a means of facilitating the information transaction between different codifications. The Internet is considered a substantial factor in enhancing the communication performance between different codifications.

When there is only one master with its main type of information to be exchanged the Internet is useful. The Newt model suggests that this is because there will be only one kind of method of communication, which means also one dynamic required for all this process. Thus translating this type of information into participants is enhanced by the availability of the Internet. Using the Internet can support the process of translating the codification from one participant to others and it therefore simplifies the work of the translation regime. The Newt model states that this is true when there is only one master participant in the collaborative research. From the survey results in ACSys CRC, it has been found that if there are more than one master and when there is a horizontal conflict among these masters the Internet is not helpful in the translation process.

The Internet is a tool which can simplify the task of the CRC in functioning as a translation regime from the master to the slaves. Moreover, the Newt model, based on the survey results, states that the Internet is also playing a role in the process of imposing the codification of the master on the slaves. This simplifies the process of information transaction from the master to the slaves. In the case where there are many masters in a conflicting situation, the Internet cannot help to solve the problems. On the contrary the Internet may make the problem even worse. The Internet may increase the level of conflict in the dynamics of the CRC, which may make collaboration more difficult or ineffective.

In both the CRC QW and the CRC WS, the Internet provides a well-codified method of communication, which eases the process of translating the codification from one participant to other participants. The Internet proves to be successful in these two CRCs where it can provide the master with better access to slaves' codification in information transaction and can help enforce the slaves' use of the new codification introduced by the master. In the CRC QW the Internet has been found to be conducive in creating and supporting the master to slave relationship. The one master in this CRC, the GRDC, has employed the Internet to codify the entire information transaction within the web of collaboration and thus strengthen its position as the master. The same applies in the CRC WS. In this CRC, the BHP-created Internet based information system, which is called IPMIS, has successfully codified the process of information transaction.

The Internet is better and more widely used in the ACSys CRC than in the other two CRCs under consideration. In the ACSys CRC the Internet is used extensively, even to conduct research projects, which means a total codification of nearly all aspect of the communication method. However the ACSys CRC ceased. The Newt model explains this by contending that the Internet was unable to support the ACSys CRC in functioning as a translation regime. In fact the problem is because the dynamics of the process of information transaction in the ACSys CRC were far too complicated compared to the other two CRCs under consideration. In the ACSys CRC there were two dynamics simultaneously playing in the process of codification of information transaction. Thus there was no clear identifiable method of communication which had to be codified by using the Internet information system, making the Internet unable to be used properly as an instrument to support the role of the CRC as a translation regime. The problem at the ACSys CRC was caused by the existence of the conflict in the process of codification of the method of communication (which determines the dynamics). This was caused by the type of information being exchanged which was also conflicting in this particular CRC.

To summarize, the Newt model has been used to explain the process of information transaction and the importance of the information system, which contribute to the success and failure of the CRC collaboration from an information perspective. The Newt model stresses that a master to slave relationship exists due to an asymmetry of the information capacity among members within the CRC collaboration. However this master to slave relationship is also the key to a success in the CRC collaborative research partnership. The Newt model again reveals that the role of the type of information may determine the success of the collaboration. It has also been found that the origin of this type of information must be from a participant which later will have to master the entire CRC collaboration. Thus the entire operation of the CRC must be limited to the transaction of this type of information through the translation of a codified method of communication (of this type of information) to the other participants of the CRC (which are categorized as slaves).

For the Newt model the problem encountered in the CRC program is normally related to the inability of the master to impose full codification of the transaction of information within the collaboration. When the transaction of information is uncontrolled, some problems will arise. This is because the other participants within the collaboration start to increase their information capacity beyond the control of the master. An example of such a situation is when two participants, with quite a significant level of information capacity and in horizontal competition with a similar interest towards a particular type of information, both becomes participants of the CRC. This may bring about a condition where the information capacity possessed by the master is not sufficient to impose full codification of the information transaction process of the collaboration. The Newt model proposes that this situation may create a less conducive and less productive collaboration.

9.3. CONCLUSIONS

This chapter has presented a comparative analysis of three CRCs case studies using the Newt model. For the Newt model the CRC is a master to slave relationship. Creation of the collaboration is caused by the need to improve the 'value' of a particular type of information. Such an intention normally comes from a participant, which later has to become the ‘master’, the other participants will have to play the role of ‘slaves’.

The Newt model further suggests that a master to slave relationship is required for the successful operation of a CRC. This master wants to increase the value of its particular type of information because it wants to maintain its position in a particular field and this can be achieved by making its information the most valuable compared to that of others. However in order for this to become possible the master has to 'mix' its information with others, but the process of mixing these bits of information must be under the full control of this master. If and only if such conditions can be created, can the CRC operate properly. The Newt model suggests that the stronger the master and the weaker the slaves, thus the purer their master to slave relationship will be, in terms of information capacity, and the more likely it is that the CRC collaboration will be successful. This is because the CRC is able to play its role as translation regime for the master in order to strengthen its position (as master) properly.

From the previous three CRCs, it has been found that the Internet played an interesting role in the master to slave relationship. The Internet strengthens the master position in mastering the process of information transaction. However, the Internet may contribute to the distribution of conflict (in cases where opposing dynamics exist) to the entire CRC collaboration.

CHAPTER 10: CONCLUSIONS, POLICY IMPLICATIONS AND SUGGESTIONS FOR FUTURE WORK

This chapter draws some conclusions from the previously derived theories and survey results. The thesis has set out both literature research and conducted several case studies. The literature review covered the fundamental understanding of innovation, inter-sectoral collaboration, and information. The theories of collaboration among participants specifically from academia, government and industry have also been covered. The main objective of the literature review was to study the under emphasized process of information transaction and the importance of the innovation related information systems in the Australian CRCs. Section 10.1 describes the general conclusions while section 10.2 describes the potential policy implications that follow from the discussions and findings in this thesis and section 10.3 describes some suggestions for future work.

10.1. GENERAL CONCLUSIONS

The thesis has investigated the process of information transaction in the collaborative research partnership. The thesis has attempted to extract the main features in such a collaboration from an information perspective. The central theme of the thesis is to understand the form and dynamics of collaboration from an information perspective that is the method by which information is transacted among participants within this collaborative partnership. Collaboration is seen as a process where there is an activity of information processing and this activity is the nucleus of the collaboration itself. Thus right from the start to its conclusion, information processing is the main activity in the collaboration. Because information processing is the “motor” of the collaboration so the need to have an information system become necessity. The thesis specifically took the collaborative research partnership between academia, industry and government agencies in Australia under the CRC programme as a case study.

The thesis contends that the 'information perspective' embodied in the Newt model has value in answering the research questions listed in Chapter 1. The general argument is that the role of the information systems in a collaborative research partnership is crucial especially when participants have a diverse range of imperatives and expectations. The hub of this argument is that the collaboration is itself an information activity where all participants are engaged in the transaction of information. Information can be understood as the commodity which is the most important element in the collaborative activity.

The thesis explores how collaborative research activity can be seen from an information perspective and furthermore how each participant interacts with others based on the information they transact. The literature review also covers some examples of the collaborative research partnership especially by investigating how people communicate and how the information is transacted in such a collaboration. The objective of the thesis is to investigate exactly how the participants in specific collaborations are interacting from an information perspective. Based on three case studies, the thesis has extended several theories and concepts. This leads to an understanding that a collaborative research partnership by involving participants from different types of organization is actually a complex process of information transaction, which may include information exchange and information upgrading as well as information gathering.

The success (or possibly failure) of such a collaborative research partnership is dependent on how well the participants can play their role in the process of the transaction of information.

Based on this consideration, the thesis advances new ideas in seeing the differences among participants in collaborations from an information perspective.

The thesis has assessed the collaborative research partnership by taking three CRCs as a case study. The research about the CRC by using the information perspective is novel and has been used to develop the so-called 'Newt' model. This model is proposed to better understand how participant transacts information with each other in the collaborative research partnership at the CRC, how this interaction may affect the performance of collaboration, and how information systems can be better managed. This model has been tested in the three CRC case studies.

The main concept under the Newt model is considering the CRC as an arena of information transaction where there is a participant with the intention to dominate the entire process. This participant is labelled as the 'master' and the other participants are labelled as 'slaves'. Thus from this perspective, a successful CRC is a master to slave relationship. The master is the participant which has the largest capacity of a particular type of information which will form the main issue in the CRC collaboration, while the slaves, obviously, are the participants which have a lesser information capacity.

The Newt model has developed some concepts for understanding the interaction between participants in collaborative research partnerships such as CRCs from an information perspective. Firstly is to investigate the **type** of information, which triggers the collaboration. In the three CRCs case studies there was a particular type of information which became the main attracting force for people to join the CRC.

Secondly, the thesis has concluded that the process of information transaction in the CRC must be conducted through a **particular method of communication**. This method is dependent on the type of information being exchanged and the organization. How people do this is different within each organization, that is, university people differ from those in business and the PSR people. The thesis labels this difference in the method of communication as **codification** (in method of communication). Thus each participant has its own codification in its method of communication.

The Newt model further suggests that the task of the CRC is to function as **a translation regime**, which has to translate the different available codifications to others and, in executing this task, the CRC has to be controlled by the master. Because this codification is dependent on the method of communication and this is again dependent on the type of information being exchanged, the thesis states that the main task of the CRC is to translate the type of information submitted by the master to other participants in the collaboration.

For the Newt model the nucleus of CRC activity is in the so-called 'Information Mixing Pot'. This is a conceptual place where the information coming from all participants in the CRC collaboration is mixed. In the mixing process, information coming from each participant is compared with the type of information submitted by the master. This process of information mixing is repeated in the course of the CRC operation. The control imposed by the master is by always comparing the new incoming type of information to this Information Mixing Pot and also to all new types of information created from this mixing process with the type of information submitted by the master.

The translation regime has two main tasks. The first task is to **detect all available codifications** (of method of communication) of the slaves, which obviously corresponds to the type of information within the collection of the slaves. The second task is **to select** which one of these codifications can be used to translate the codification from the master. This enables the translation regime to determine which type of information in the collection of the slaves is beneficial in order to improve the "value" of the type of information submitted by the master. These two tasks explain why, when there is more than one master in a conflicting situation the CRC will never work (as in the ACSys CRC). The process of translating the codification, which consists of the process of detection and selection mechanism, can never be conducted properly under these circumstances. A new kind of dynamics may occur given that both detection and selection mechanisms are challenged by other codification (which are coming from the other masters). This situation is for example in the case when the masters are in horizontal competition. In such a case the required type of information is quite similar, making the codification in the method of communication also similar but conducted by different powerful participants (the masters) with the same intention in order to master the process of detection and selection from the slave layers of the communication codification (in order to impose as strong as possible control on the slaves).

The task of the CRC as the translation regime is not only to go through each participants' layers of communication codification but also to do the same thing to each participant. This process must be conducted sequentially in a regular cycle. Only by doing it this way can the type of information submitted by the master be understood by the slaves. The thesis has developed the so called 'spider diagram', as an analytical method to visualize the process of selecting and detecting the codification used by the slaves and how the master by using the CRC can impose its own codification on the entire collaboration.

From the above concept the mechanism of master to slave relationship at the CRC can be understood, where the master can impose its codification in the method of communication on the slaves. This also enables the master to limit the mixing of information conducted by the slaves in order to create a particular new type of information. The reason is that the master's own codification is always the main ingredient of the slave’s codification (of method of communication) while the newly created type of information will have to be compared to the type of information submitted by the master. This creates a double control mechanism allowing the master to fully control the dynamics of the information transaction while at the same time preventing the slaves from creating their own codification beyond the one which is allowed by the master. Limitation other codifications will limit the slaves in the creation of their information mixing and may limit their level of innovation.

Thus to enable effective operation a CRC has to function as a translation regime for one master only, in order to guarantee that there is only one codification required to be translated to other codifications in the entire collaboration. This also corresponds to the need to have only one master. The existence of more than one master may create another type of codification, which may create problem for the CRC to function properly as a translation regime. Thus the existence of multiple masters in horizontal competition may not be conducive to allowing a proper CRC operation.

The mixing of information may create a new type of information and this may lead to innovation. For the Newt model, this philosophy is the trigger for the master to set up the CRC collaboration. By mixing its type of information with other types of information, a new type of information may be created which may be beneficial for the master, provided the process of mixing the information is under the control of the master. By using this method, the master can limit the level of mixing of the information by the slaves. Therefore the information capacity of the master may increase to a significant level, while the same does not apply to the slaves. This kind of interaction is the key to the master to slave relationship understanding of CRC collaboration.

The level of master to slave relationship varied from one surveyed CRC to another. In the CRC WS the master was BHP, which triggered the collaboration by introducing a particular type of information, which then became the main topic of collaboration. The thesis has shown the working of the CRC WS as a translation regime for BHP as a master in this CRC by using the spider diagram. It has been shown the way BHP can control the process of detection and selection of all possible codifications which are used by all participants and it has also been shown that BHP can impose its codification on all participants.

The same applies to the second CRC, which is the CRC QW. In this CRC the master is the GRDC. However the GRDC itself is a participant which became big and powerful on the basis of strong support from smaller information clusters of information capacity. Using the spider diagram, the thesis has shown that the CRC QW has functioned properly in assisting the mastership of the GRDC.

In the last CRC, the ACSys CRC the situation is interestingly different. There was a master to slave relationship in this CRC. The master was a participant with strong information capacity while the slaves were inferior in terms of information capacity. However there were many masters in this CRC, in fact there were four of them. These four masters were trying to impose their codification on the entire CRC and trying to use the CRC as the translation regime under their command. The problem was that three of the masters were in horizontal competition which had created the existence of a multi-dynamic method of communication that made it impossible for this CRC to function properly. The spider diagram has been used to explain that under such circumstances the ACSys CRC finally ceased its operation.

The role of the Internet information system has been explored in the thesis. It is interesting that from the previous three CRCs, the Internet did play a role in supporting the creation of the master to slave relationship. The Internet also plays a significant role in making it easier for the master to control the slaves in the process of information transaction. The Internet has also been found to be an important element in strengthening the master. The Internet is a way to strengthen not only the process of codification but the enslaving of the slaves, making them more dependent on the codification imposed by the master in the entire collaborative research entity. In the previous three CRCs such a kind of situation has been observed.

The Newt model suggests that the role of the Internet information system can be twofold. On one hand, it is helpful in creating a better environment for a master to slave relationship in the collaboration. The Internet information system can strengthen the master's position and can support the master in exercising its mastership in the process of the information transaction. On the other hand, the Internet information system has the potential to expose conflict in the information transaction more readily to all slaves of the collaboration. It must be noted that collaboration under the Newt model is an activity of information transaction and the Internet information system, which plays a role in such a process, can be very influential in determining the success or failure of the collaboration. The case study at ACSys CRC strengthens the argument that the type of information is the main determinant in the CRC collaboration.

10.2 POLICY IMPLICATIONS

The Newt model has allowed us to observe the CRC collaboration from a different angle. Based on the discussion of this model, there follows six policy implications. The policy implications stress the importance of investigating the level of information capacity of each participant and the role of the information system.

In order to be successful, the Newt model suggests that general policies for the CRC should have the following orientation; let the CRC collaboration build and maintain the master to slave relationship.

In the first instance, the Newt model suggests that the government should pay attention to the importance of the particular type of information being exchanged in the CRC collaboration. It is this element, which is basically the main determinant for triggering people to get into collaboration along with the funds provided by government and it is this element which may further contribute to the success (or possibly failure) of the CRC collaboration.

The government must also pay attention to the fact that the type of information created in a CRC collaboration is dependent on the role played by a particular participant called the master. The master delivers the main type of information which triggers the collaboration and in the course of the programme it determines what type of information can be collected by other participants (the slaves) in order to improve the "value" of their type of information (for example: to create innovation). However, planning to make a slave become more innovative allowing them in a CRC collaboration where there is a giant (large company) may not be producing a significant result for that slave.

The second consideration is that even though CRC membership is voluntary, the fact is that a participant joins the collaboration, the participant becomes involved in the codification set by the master. Thus once this participant candidate has entered the collaboration and has signed the agreement to join the CRC, this means from the Newt model, that this participant has let itself become enslaved by the master in the CRC collaboration. This is because the CRC itself, according to the Newt model, has been set up through the strong intention of a participant which has the largest information capacity to impose its type of information on other participants in the society with the same field of interest.

Moreover this master also has the intention of improving the value of its type of information, and this can only be achieved by mixing it with some other types of information. It is interesting to note that the Newt model suggests such an intention is based on the other intention which is controlling the process of the mixing up of the information. Thus the CRC becomes the medium to support such control from the master against the other participants (the slaves).

In general, the Newt model suggests that the government policy for CRC must consider two important elements:

- The government should be aware that there is an asymmetry on the basis of information capacity, and this will affect how the information is transacted in the CRC. Careful consideration must be taken when partnering small to medium local participants with giant multi-national companies.
- The master to slave relationship should be supported rather than reduced or abolished. Reducing and/or abolishing this relationship may mean an end to a CRC operation because this is the main driver which gives birth to and sustain a CRC collaboration.

The CRC itself is a medium which plays a role to support the master in achieving and sustaining its position as master in the collaboration. Thus the government's funding must be allocated as such so that it helps to create a more conducive environment so that the master can strengthen its position as master and enhance its capability to exercise mastership among other participants (the slaves). Thus government policy must also pay attention to the funding that, from an information perspective, there are two kinds CRC's partners, the master and the slaves. Categorizing the membership on the basis of the information capacity must become the new item for government when assessing a CRC application.

Historically speaking the CRC programme was addressed by government to anticipate some weaknesses in the Australian national innovation system. The CRC collaboration was set up under some concepts, which have been listed in section 4.1. The detailed policy implications will be developed by comparing those CRC's basic concepts with the new kind of perspective in viewing the CRC collaboration introduced by the Newt model.

The CRC concept # 1[1]. To create a system of world class applications-oriented research centres by linking together outstanding research groups from public and private sectors.

<u>The Newt Model in response to the CRC Concept # 1:</u> The Newt model bases its concept on the fact that the CRC collaboration is basically a master to slave relationship. Thus each organisation has its capacity of types of information, which may determine its role in the CRC collaboration, either as a slave or as a master.

Policy Implication # 1: Assessment of membership based on a participant's information capacity is important and necessary. At the beginning of CRC application, the government has to detect which participant is likely to become master and which participants are likely to become slaves. The mapping of a participant's position on the basis of a participant's information capacity vis a vis others is important. This can be done for example by a careful review and comparison of the participant's company profiles.

[1] For detailed description on the CRC concepts see again page 85

The CRC concept # 2. To enable each participating group to retain its separate institutional affiliation, but each centre to constitute a collaborative integrated research team

The Newt Model in response to the CRC Concept # 2: The Newt model suggests the role of the CRC as a translation regime, but only for the benefit of the master. Each institution creates different types of codification, which requires a CRC for conducting a translation function, in the process of the information transaction. However it must be noted that this CRC penetrates each codification in order to pass the 'message' from the master. The Newt model further suggests that this may affect the codification of each in the collaboration.

The Newt model also suggests that joining the CRC collaboration may add a new codification to each participant. This new codification allows the possibility for each participant to have two different codifications simultaneously. These are the economy and the scientific codifications. The scientific part considers the CRC collaboration as a way to have high quality scientific results achieved through this collaboration. The scientists may see the CRC as a 'slot' where they are able to 'market' their ideas and when these scientists market their research results to industry it means that they have opened up new possibilities for new problems in their Information Mixing Pot, such as the need to solve new problems and the need to have new ideas. Therefore to anticipate this lack of information they need to collaborate and help industry in solving their problems, because this basically helps them to find the solution for their new problem (because this adds more reference into their Information Mixing Pot, to be compared with the new information flowing into their Information Mixing Pot).

For the industrialist (the economy part) the CRC is a way to commercialize the new technology being developed by their in-house research task force augmented by support from the scientists from outside the industry but paid by industry via this CRC collaboration mechanism. For industry, success is when high profit can be achieved from the new possible innovation developed in the collaboration. Again for the industry such a condition is conducive for them in order to have a new type of information created, as for example the creation of more new inventions and to create a new breakthrough in technology development while solving their own technology and technical problems related to business. It is well known that in reality the demarcation between the role of each participant will be blurred owing to intensive interaction between roles and functions of each participant. The university is no longer the only producer of knowledge but also has started to market it. Meanwhile industry sometimes conducts its own research in its own research laboratory. The Newt model suggests that the CRC as a translation regime is playing a role in blurring the role of each institution. In other words, the Newt model suggests that such an institution's role may change in the course of the CRC programme.

As noted, the Newt model suggests that the master's involvement may penetrate the institutional codification of each slave. This means that the codification which is used by slaves may be affected by codification from the master through the CRC collaboration. For the master this is beneficial because they can control the entire activity of information transaction of the slaves. The slaves must be careful because this may limit their capability in the creating of new types of information for their benefit.

Policy Implication # 2: From a government perspective, a situation must be considered because it may affect the government's plan to have mutual collaboration as for example in national high technology development. For government, success is when there is a working political mechanism which can regulate the interaction between these two components (economy and science) in a more equal pattern. Especially when dealing with a large economy component (for example a big, multinational company), interaction, if possible, must be arranged as such so that the information transaction is not too concentrated into these large economy components.

The Newt model suggests that such effort is difficult. However an assessment as to what extent a master may exploit the slaves in terms of their asymmetry of information can be conducted by the government. This assessment can be done at the beginning of the CRC application and during the continue reviewing of CRC in it's operation. Moreover the government should assess the situation of information asymmetry for a renewal of CRC application. The second policy implication stresses that, at the beginning of CRC application, the government should request the likely masters to provide all possible explanation for the way this participant conducts the process of information transaction. It must be noted that the government is in position to foresee the level of information capacity of CRC's participants before the CRC collaboration application can be approved. From this kind of assessment the government can predict to what extent the master to slave relationship is likely to happen. This is to avoid the case when the proposed CRC is likely to become an arena of conflict among masters.

The CRC concept # 3. To focus the research on challenging research fields and areas which underpin existing or emerging industry sectors.

<u>The Newt Model in response to the CRC Concept # 3:</u> The Newt model suggests that owing to the master to slave relationship, it is possible that the direction of the research is driven by the master. Thus the research to be conducted is likely to focus towards the improvement of value of the particular type of information submitted by the master.

Policy Implication # 3: The government should make an assessment, based on information capacity, of which participant is likely to dominate the entire collaboration. This assessment should be done at the beginning of CRC applications and at every renewal of CRC funding. Furthermore the government should assess to what extent the type of information which is submitted by this master may be valuable to a particular national need. Only when this participant has relevance to such a national need should the CRC application be approved.

The CRC concept # 4. To co-locate the groups participating in each centre, wherever possible, to promote effective co-operation and to enable expensive facilities to be used efficiently and without unnecessary duplication.

<u>The Newt Model in response to the CRC Concept # 4:</u> The Newt model suggests the role of the CRC as a translation regime to enhance the effectiveness of co-operation by easing the process of codification among different participants. This also reduces the possibility for unnecessary duplications. However the Newt model also suggests the possibility of the master would be better at enslaving the slaves by using the CRC as a translation regime. Moreover, the Newt model suggests the role of the Internet as positive in enhancing the effectiveness of co-operation. This is because the Internet plays an important role in making the slaves more easily enslaved by the master, given that the Internet is able to make it easier for the master to impose its way of codification on the slaves. The Newt model with its emphasis on an information perspective warns that sharing of an expensive facility may also allow the owner of this expensive facility to impose a particular codification in the information transaction. This at later stages may create a kind of master to slave relationship. The Internet may be very supportive for creating such a condition. In the case study of three CRCs, expensive equipment has always come from the master.

Policy Implication # 4: The government should be aware that an effective CRC operation does not necessarily mean an information transaction process with equal benefits for all participants in the CRC. A participant in a position as a master may get a more effective way to enslave the other participants through a CRC collaboration. For example sharing expensive equipment may be a way to enslave another participants rather than to help these participants (for example to become more innovative). The best way is to make sure that the government has a clear idea of all types of information in the possession of all participants. Practically, this would be nearly impossible or very difficult given the nature of the CRC collaboration. A possible way to do so would be to treat the participants differently on the basis of the critical type of information at their disposal. This can be done all the way of CRC's operation.

The CRC concept # 5. To locate the centres on or adjacent to university campuses wherever possible, so as to encourage precinct development around universities and enable the centres to contribute as fully as possible to the strengthening of educational programmes.
<u>The Newt Model in response to the CRC Concept # 5:</u> The education programme to Newt model is part of the information transaction. From this perspective, the university may become the slave. The master may impose the codification of the method of communication on the university's codification. Moreover when the university is in the slave position the Newt model suggests that it is unlikely that this university would be able to have full freedom in directing the creation of a totally new innovation or a new dimension for research. On the contrary this university may become part of the master's codification.

The type of information which may be collected in this way is much more limited than using other ways. To a limited extent, from the Newt model perspective, the CRC programme may not necessarily be an excellent way to help generate new innovation and make the university as a producer of knowledge become more innovative and productive. In terms of productivity, the type of information being generated by a university participant remains limited and controlled by the master.

Policy Implication # 5: When the government intention is to increase the level of information (and knowledge) capacity of the university, it must be noted that the CRC model may not necessarily be conducive for the achievement of such a result. Letting the university become a participant of the CRC, is similar to letting the university be codified and limited in terms of its freedom to create new information and knowledge, which obviously is important in an education institution. A CRC collaboration may limit such freedom and on the contrary create new codification for the university which may reduce its level of excellence as a locus for generating innovation. Given that the master to slave relationship is the "motor" of the CRC operation, the government, when partnering the university along with others, must be careful. If the government wants the university to remain the locus of innovation and knowledge creation with full freedom for their pursuance, then it must be made sure that the university is not the slave in the CRC collaboration. This can be done by avoiding the university having a collaboration with a potential master. The Newt model also suggests that excessive reduction of government funding for university research may force the university to get support through the CRC model and without carefully pairing with other participants, the university may become a slave. Thus funding the university through a collaborative research partnership such as CRC must be conducted in a careful way. Therefore careful consideration of university's information capacity compared to others at CRC collaboration has to be the main attention of the government at the beginning of CRCs' application.

The CRC concept # 6. To ensure that each centre is led by a director who would be an experienced and highly regarded researcher with appropriate management skills.

<u>The Newt Model in response to the CRC Concept # 6:</u> For the Newt model, the Director of the CRC is the translation agent who has the task to translate the codification from the master to the other participants of the CRC (the slaves). Thus the skills of the Director and his/her role are certainly important for the CRC collaboration.

Policy Implication # 6: Officially the government is not in a position to select the CRC Director. However, the government, at the beginning of CRC application, should recommend that the CRC participants select the Director, if possible, from the participant which is likely to become the master of the CRC collaboration. This is the best way the government can support the role of master in the CRC collaboration.

In general, in order to ensure a successful CRC collaboration the government is required to identify the master at the beginning of the CRC collaboration and then to make sure that a permanent master to slave relationship in the CRC can be maintained during the course of collaboration rather than trying to remove or reduce it. When the government is keen to develop a particular type of information, for example to create innovation in a particular field, then it has to establish a CRC with a master which is really excellent in this particular field.

The policy implications of this analysis pay attention to the following two important factors, <u>the need to maintain the master to slave relationship in the CRC</u> and <u>the government has to reduce the possible existence of any opposing dynamics which may be less conducive to enable the CRC to operate properly</u>. The funding allocated by government must be aimed for the achievement of both objectives. It has to support the master in maintaining its position as master and avoid the selection of other participant which may challenge the master's position (in order to avoid the creation of new opposing dynamics). These considerations are particularly important when the government wants to have a specific goal, such as to make a particular participant excel in a particular field.

The government has to realize that the master will dominate the entire information transaction and the slaves will get limited information (in terms of capacity and its variation). Thus when the government is considering innovation as an important aspect in a CRC programme it must be noted that significant innovation can only be created by the master, while the slaves can only create limited innovation.

Moreover the Newt model, suggests that when partnering a local participant with a giant multinational company, extra precautions must be taken, especially when the government has the intention of increasing the level of information capacity of this local participant and making it become more innovative. Owing to a strong master to slave relationship, it is likely that the local participant will get enslaved by the foreign master, making them become less innovative and the master will have a chance to strengthen its position as master in this particular field. This is because through the CRC the master will get access to the codification of information transaction used by the slaves (the local participants), and the Newt model suggests that given that the master has a larger capacity of information, it gives the master the capability to impose its codification on the slaves (the local participants) and to enforce the usage of the master's codification of the information transaction. In this way the master can easily control the process of mixing several types of information by the slaves.

10.3. SUGGESTIONS FOR FUTURE WORK

The main idea of the Newt model is to consider a collaboration involving multiple participants as a process of information transaction. The process of information transaction is dependent on the information capacity of the participant in the collaboration. Based on the information capacity some participants can be labelled as ‘masters’ and others as ‘slaves’

This thesis has limited itself that the availability of funding is a given factor and thus assuming that for a CRC to exist, there must be funding available from the government. However, for a future work, the Newt model suggests that the master may have intention to dominate the entire information transaction by other means such as funding. It is hypothesized that a master may be willing to offer the highest level of contribution (both as in cash and in kind). Such a condition may allow the possibility for the master to be more in control of the process of the information transaction and codification. A detailed analysis of the extent that funding can be regarded as a kind of 'information' transaction and codification may be very interesting. Such kind of topic may further test the capability of Newt model in explaining the process of collaboration from information perspectives.

The Newt model has been applied to three CRCs only. The features listed here may not be found in other CRCs. For the Newt model if there is no 'master' to 'slave' relationship, could mean that the process of information transaction may no longer be a process for the improvement of a particular type of information introduced by the 'master' by using the CRC as a translation regime. Thus the innovation created may no longer be dependent on one 'master'.

The Newt model is not expected to be *a generic model* that can explain the process of information transaction in *every* CRC. However, the basic idea is that in any collaboration-work involving master-to slave relationship and with the existence of an entity which plays role as a translation regime, the Newt model can be utilised as an analytical tool to assess the process of information transaction. To further test the validity of Newt model, a further investigation of the Newt model to other CRCs is recommended, especially those with partners from large multinational companies and/or those with a single dominant partner (in term of information capacity). Moreover an application of the Newt model to CRCs with partners having quite similar capacity of information may improve the Newt model.

REFERENCES

List of references used directly or quoted for the thesis.

1. Ahuja, G., (2000), *Collaboration Networks, Structural Holes and Innovation: A Longitudinal Study*, Administrative Science Quarterly, Volume 45, Issue 3, pp. 425-455.
2. Albertini, S., and Butler, J., (1997), *The Type of Knowledge Used in R & D Networking and Innovation Activities*, in Technology, Knowledge and Innovative Organisations, Butler, J and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
3. Allen T.J., (1993), *Managing Technical Communications and Technology Transfer: Distinguishing Science from Technology*, in Managing the Flow of Technology, Allen, T., (editor), MIT Press, London, UK.
4. Allen, D., (1997), *Social Dimensions Change*, in The New Research Frontiers of Communication Policy, Lamberton, D.M., (editor), Elsevier, Amsterdam, The Netherlands.
5. Allen, T.J., (1993), *Managing Technical Communication and Technology Transfer: Distinguishing Science from Technology*, in Managing the Flow of Technology, Allen, T., (editor), MIT Press, London.
6. Antonelli, C., (1997), *Localised Knowledge and Information Network*, in The New Research Frontiers of Communication Policy, Lamberton, D.M., (editor), Elsevier, Amsterdam, The Netherlands.
7. Antonelli, C., (2000), *Collective Knowledge, Communication and Innovation:The Evidence of Technology District*, Regional Studies, Volume 34, Issue 6, pp. 535-553.
8. Antonelli, C., Geuna, A., and Steinmuller, E., (2000), *Information and Communication Technologies and the Production, Distribution and Use of Knowledge*, International Journal on Technology Management, Volume 20, Nos.1/2 pp. 72-74.
9. Arora, A., and Gambardella, A., (1990), *Complementary and External Linkages: The Strategies of Large Firms in Biotechnology*, Journal of Industrial Economics, 38:361-379.
10. Assimakopoulos, D., and Macdonald, S., (1999), *Collaboration and Innovation Networks in Esprit*, Prometheus, Volume 17, No. 3, pp. 299-307.
11. Australasian Welding Journal (1998), Volume 43, Second Quarter, 1998.
12. Bolisani, E., and Scarso, E., (2000), *Electronic Communication and Knowledge Transfer*, International Journal on Technology Management, Volume 20, Number 1/2, pp. 116-133.
13. Borck, J.R., (2000), *As e-collaboration tolls mature, they can help you workout a competitive advantage*, Info World, Volume 22, Issue 48, pp. 73-74.
14. Brot, J., (2000), *The New R & D: What it means for you*, Network World, April 24, pp. 87-92.
15. Brown, S.L, and Eisenhardt, K.M.,(1995), *Product Development:Past Research, Present Findings and Future Directions*, Academy Management Review, Volume 20, Number 2, pp. 343-378.
16. Chesnais, F., (1996), *Technological Agreements, Networks and Selected Issues in Economic Theory*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V., (editors), Edward Elgar Publishing Company, Cheltenham, UK.
17. Child, J., and Faulkner, D., (1998), *Strategies of Cooperation*, Oxford University Press, London, UK.
18. Coles, A. M., Dickson, K., Lawton Smith, H., (1997*), Adapting New Realities in Inter-Firm R & D Collaboration*, in Knowledge, Technology and Innovative Organisation, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
19. Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V., (1996), *Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation*, Edward Elgar, Cheltenham, UK.
20. Cortese, A., (2001), *Masters of Innovation*, Business Week, New York, Spring 2001, Issue 3276A, pp. 158-165.
21. CRC Compendium 1996, DIST, Canberra, Australia.
22. CRC Evaluation Steering Committee (1995), Changing Research Culture, Canberra, Australia.
23. CRC for Advanced Computational System, Annual Reports 1996/97 and 1997/98.
24. CRC for Material Welding and Joining, Annual Reports from 1993/94 to 1997/98.
25. CRC for Quality Wheat Newsletter, May, 2000.
26. CRC for Quality Wheat Products, newsletter issue 2, December, 1998.

27. CRC for Research Data Network, Annual Report 1997/98, 1998.
28. CRC for Welded Structures, Annual Report 1998/99, 1999.
29. CRC for Welded Structures, Brochure 1999-2007, 1999.
30. CRC Program guidelines for applicants 1998 round, DIST, 1998.
31. CRC Program, Selection Rounds 2004, Guidelines for Applicants taken from https://www.crc.gov.au/about retrieved at June 14, 2005
32. Dijkhuis, W., (1982), *Innovation, Its Evolution and Present State*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
33. Dodgson, M., (1998), *Technological Collaboration:Challenges for the Future*, paper for the 2nd Annual APEC Technomart Conference, Taipei, 19-26 January.
34. Faulkner, W., and Senker, J., (1999), *Making sense of diversity: Public-private sector research linkage in three technologies*, in Research Policy, 23: 673-695.
35. Feldman, M.P., (1994), *The Geography of Innovation*, Kluwer Publishing, Dordrecht, The Netherlands.
36. Fisscher, O.A.M., Kerssens-van Drongelen, I. C., de Weerd-Nederhof, P.C., (1997), *Describing The issues of Knowledge Management in R & D:Towards a Communication and Analysis Tools*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
37. Freeman, C., (1982), *The Economics of Industrial Innovation*, MIT Press, Cambridge, MA, USA.
38. Freeman, C., (1991), *Networks of Innovators: A synthesis of research issues*, Research Policy, 20: 499-514.
39. Fristch, M., and Schwirten, C., (1999), *Enterprise-University cooperation and the role of Public Sector Research in regional innovation system*, in Industry and Innovation, Volume 6, Number 1, pp. 69-83.
40. Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., and Trow, M., (1994), *The New Production of Knowledge*, SAGE Publications, London, UK.
41. Gilbert, A., (2000), *On-Line collaboration tools help simplify product design*, Information Week, April 24, pp. 130-135.
42. GRDC Annual Report 1998/1999, GRDC Secretariat, Canberra, Australia.
43. Hakansson, H., and Shenota, I., (1995), *Developing Relationship in Business Networks*, Routledge, London, UK.
44. Hamel, G., Doz, Y L., and Pralahad, C.K., (1989*), Collaborate with Your Compatitors and Win*, Harvard Business Review, January-February, pp. 133-139.
45. Hanson, D., Steen, J., and O'Donohue, W., (1999*), Management of Basic Research and Development: Lesson from the Australian Experience,* Prometheus, Volume 17, Number 2, pp. 187-197.
46. Hippel E., von (1988), *The Source of Innovation*, Oxford University Press, New York, USA.
47. Houten, R., van (1982), *The Requirement for Specialised Information in an Innovative Process: Research and Technological Application*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
48. Howells, J., (2000), *International Coordination of Technology Flows and Knowledge Activity in Innovation*, International Journal on Technology Management, vol. 19, Nos 7/8, pp. 806-816.
49. Koschatzky, K., and Sternberg, R., (2000), *R & D Cooperation in Innovation Systems- Some lessons from the European Regional Innovation Survey (ERIS)*, European Planning Studies, Volume 8, Issue 4, pp. 487-501.
50. Krupp, H., (1982), *Economic and Societal Consequences of Informatisation,* in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.

51. Lamberton, D., (1996), *The Economics of Information and Communication*, Edward Elgar Publishing, Cheltenham, UK.
52. Landau, R., (1982), *The Innovative Milieu*, in Managing Innovation: The social dimensions of creativity, invention, and technology, Lundstedt, S.B., and Colglazier, E.W., (editors), Pergamon Press, New York, USA.
53. Langford, C.H., and Langford M.W., (1997), *University, Industry Government relations in Canadian access to Megascience Research Environments*, available from http://www.chem.ucalgary.ca/groups/langford/megasci.htm retrieved at July 14, 1998.
54. Lawton Smith, H., (1997), *National Laboratories and Innovative Networks*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
55. Lawton Smith, H., Dickson, K., and Lloyd Smith, S., (1991), *There are two sides to every story: Innovation and Collaboration within Networks of Large and Small Firms*, Research Policy, vol.20, 5:457-482.
56. Leveque, F., Bonazzi, C., and Quental, C., (1996), *Dynamics of Cooperation And Industrial R&D: First Insights into The Black Box II*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V.,(editors), Edward Elgar Publishing Company, Cheltenham, UK.
57. Leydesdorff, L., and Etzkowitz, H., (1997), *A Triple Helix of University-Industry-Government Relations*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
58. Leydesdorff, L., and Etzkowitz, H., (1998a), *The Triple Helix as a Model for Innovation Studies*, Science and Public Policy, Volume 25, number 3, pp. 195-203.
59. Leydessdorff, L., and Etzkowitz, H., (1998b), *Triple Helix of Innovation: Introduction*, Science and Public Policy, Volume 25, number 6, pp. 358-364.
60. Ljunberg, S., (1982), *How Can a Well Organised Information and Development Service Help to Improve the Innovation Process in a Company*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
61. Lomi, A., and Prevezer, M., (1997), *Networks for Innovation in Biotechnology*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
62. Lundstedt, Sven. B., and Colglazier, William E., (1982) *Managing Innovation: The social dimensions of creativity, invention, and technology*, Pergamon Press, New York, USA
63. Macdonald, S., (1992), *Formal Collaboration and Informal Information Flow*, International Journal on Technology Management, Special Issue on Strengthening Corporate and National Competitiveness through Technology, Volume 7, Nos. 1/2/3, pp. 49-60.
64. Macdonald, S., (1996), *Informal Information Flow and Strategy in International Firm*, International Journal on Technology Management, Volume 11, Nos. 1/2, pp. 219-232.
65. Macdonald, S., (1998), *Information for Innovation*, Oxford University Press, UK.
66. Madden, G., Savage, S.J., and Coble-Neal, G., (2000), *Internet Adoption and Use*, Prometheus, Volume 18, Number 2, pp. 161-173.
67. Maguire, C., Kazlauskas, E.J., and Weir, A.D., (1994), *Information Service for Innovative Organisation*, Academic Press Inc, San Diego, USA.
68. Mason, G., and Wagner, K., (1999), *Innovation, Systems and Industrial Performance : Germany in international perspective*, in Industry and Innovation, Volume 6, Number 1, pp. 1-4.
69. Mercer, D and Stocker J., (1998), *Review of Greater Commercialisation and Self Funding in the CRC Program,* Department of Industry, Science and Tourism, 1998. Available at http://www.dist.gov.au retrieved March 9, 2000.

70. Mortimer, D. A., (1996), *Going for Growth, Business Program for Investment, Innovation and Export, Chapter 1. Introduction and Summary*, available at: http://www.dist.gov.au/events/mortimer/chapter1.html, retrieved at December 12, 1999.
71. Myers Rupert, Sir., (1997), *The Future of CRC*, over head slides from seminar Australian Academy of Technological Science and Engineering chaired by Sir Rupert Myers KBE AO FAA FTSE, November 24.
72. Niosi, J., (1996), *Strategic Technological Collaboration in Canadian Industry: Towards a Theory of Flexible or Collective Innovation*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V., (editors), Edward Elgar Publishing Company, Cheltenham, UK.
73. Nobel, Robert and Birkinshaw, Julian., (1998) *Innovation in Multinational Corporations: Control and Communication Patterns in International R & D Operations*, Strategic Management Journal, vol. 19, pp 479-496.
74. OECD 1999, *Managing National Innovation System*, OECD Paris pp.118 in Tegart W.J.Mc.G., Australian Academy of Technological Sciences and Engineering-Focus No. 110-January/February 2000.
75. Pavitt, K., (1988), *International Patterns of Technological Accumulation*, in Strategies in Global Competition, Hood, N., and Vahlne, J.E., (editors), Groom-Helm, London, UK.
76. Porter, P., (2001), *The Internet as Conference Room*, Design News, Volume 56, Issue 8, April 23, pp. 3-17.
77. Prochink, V., (1998), *Cooperation between Universities, Companies and Government in the national export Software Program-Softex 2000*, available at http://mint.mcmaster.ca/mint/readings/jan96.htm#best4 retrieved on July 14, 1998.
78. Schad, F.T., (2001), *Innovation is Bottom Line for New Collaboration Tools*, Machine Design, Volume 73, Issue 5, pp. 388-389.
79. Schmidt, T., (2000), *Collaboration fuels Innovation*, R & D, Volume 42, Issue 6, pp 8-13.
80. Schumacher, D., (1982), *The Professional Organisation as a means of information transfer, ONLINE AG, Germany*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
81. Seidl, P. R., and Longo, W. P. e.,(1999) with comments from L. Leydessdorff and H. Etzkowitz, *Comments on the Application of Triple Helix of Innovation in Developing Countries*, Science and Public Policy, Volume 26, number 2, pp. 137-139.
82. Senker, J., and Senker, P., (1997), *Implications of Industrial Relationships for Universities : A Case Study of The UK Teaching Company Scheme*, Science and Public Policy, Volume 24, number 3, pp. 173-182.
83. Slatyer, R.O., (1993), *Cooperative Research Centres: The Concept and Its Implementation*, Research Grants Management and Funding, Symposium Proceedings, Wood, F.Q., and Meek, V.L., (editors), Anutech Publishers, Canberra, pp. 121-129.
84. Staropoli, C., (1998), *Cooperation in R & D in the pharmaceutical industry, the network as an organisational innovation governing technological innovation*, Technovation, Volume 18, no.1, pp. 13-23.
85. Steward, F., and Conway, S., (1996), *Informal Networks in the Origination of Successful Innovations*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V., (editors), Edward Elgar Publishing Company, Cheltenham, UK.
86. Sutz, J., (1997), *The New Role of University in The Productive Sectors*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
87. Teece, D., (1986), *Profiting from Technological Innovation: Implications for Collaboration, Licensing and Public Policy*, Research Policy, Volume 15, 2: 125.
88. Tegart, W.J.Mc.G., (1996), *Innovation and Triple Helix***,** Australian Academy of Technological Sciences and Engineering, Focus, Number 94, May/June.
89. Teresko, J., (2000), *E-Collaboration*, Industry Week, Volume 249, Issue 11, pp.31-36.

90. The Annual Report of Department of Industry Science and Tourism 1997, available at http://www.dist.gov.au retrieved at June 18, 1998.
91. The company profile of Australian Pipeline Industry Association, APIA, member of CRC WS, http://www.apia.com.au/about retrieved at December 4, 2000.
92. The company profile of DEC-Compaq Australia, Pty, Ltd., Industry Partner of Cooperative Research Centre for Advanced Computational Systems (ACSys CRC): http://www.compaq.com.au/solutions/govtedu/education/ retrieved at December 8, 2000 and http://www.compaq.com/corporate/community/ataglance.html, retrieved at December 8, 2000.
93. The company profile of Fujitsu Australia, Pty, Ltd., Industry Partner of ACSys CRC, http://pr.fujitsu.com/en/profile/profile.html retrieved at December 8, 2000.
94. The company profile of Silicon Graphics Institute (SGI) Australia, Pty, Ltd., Industry Partner of Cooperative Research Centre for Advanced Computational Systems (ACSys CRC) avalilable at: http://www.sgi.com.au/info/ retrieved at December 12, 2000 and http://www.sgi.com/company_info/ retrieved at December 12, 2000 and http://www.sgi.com/newsroom/factsheet.html retrieved at December 12, 2000.
95. The company profile of Storage Tek Australia, Pty, Ltd., Industry Partner of Cooperative Research Centre for Advanced Computational Systems (ACSys CRC), http://www.storagetek.com/about_us/, retrieved at December 11, 2000.
96. The company profile of Sun Micro System Australia, Pty, Ltd., Industry Partner of Cooperative Research Centre for Advanced Computational Systems (ACSys CRC), available at: http://www.sun.com retrieved at December 14, 2000 and http://www.sun.com.au retrieved at December 14, 2000.
97. The Cooperative Research Centre for Advanced Computational Systems: http://acsys.anu.edu.au/ and http://acsys.anu.edu.au/corpinfo.html, retrieved at September 14, 2000 and http://acsys.anu.edu.au/education.html retrieved at September 14, 2000.
98. The CRC for Quality Wheat, Annual reports 1995/96 to 1999/00.
99. The CRC for Welded Structures Case Histories: *Improved Welding means Cheaper Gas*, available at: http://www.crcws.com.au/histories/case1.html, retrieved at November 14, 2000.
100. The CRC in brief, a List of Frequently Asked Questions about a CRC, available at: http://www.dist.gov.au/crc/faqs/index.html, retrieved at December 10, 1999.
101. The European Community, Research Technology and Development Program EUREKA available at: http://www.cordis.lu/fp5/eureka.htm, retrieved at December 20, 2000.
102. The Future of ACSys CRC, http://acsys.anu.edu.au/future.html, retrieved at September 14, 2000.
103. The International SEMATECH Corporate Information available at: http://www.sematech.org/public/corporate/history/1986.htm#may, retrieved at December 20, 2000.
104. The List of Current Operating CRC, as of October 2001, is available at http://www.dist.gov.au/crc/centres/index.html, retrieved at November 11, 2001.
105. The List of Current Operating CRC, as of June 2005, is available at https://www.crc.gov.au/Information retrieved at June 14, 2005
106. The profile of CSIRO Mathematical and Information Science (CMIS), a core member of ACSys CRC available at: http://www.cmis.csiro.au/, retrieved at April 19, 2000.
107. The Results of CRC Selection Round 2002, announced at October 3, 2001, available at: http://www.dist.gov.au/crc/2002_Selection_Round/index.html, retrieved at November 11, 2001.
108. Turpin, T., (1997), *CRC and Transdisciplinary Research: What are the Implications for Science*, Prometheus, Volume 15, No. 2, pp. 253-265.
109. Turpin, T., and Deville, A., (1995), *Research Management and Commercial Markets: Cultural Change in Australian Research Institutions*, Prometheus, Volume 13, Number 1, pp. 45-60.

110.Turpin, T., and Garrett-Jones, S., (1997), *Innovation Networks in Australia and China,* in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
111.Turpin, T., Aylward, D., Garrett-Jones, S., and Johnston, R., (1996a), *Knowledge Based Cooperation, University and Industry Linkages in Australia*, Department of Employment, Education, Training and Youth Affairs, Report Number 96/17, December, Australian Government Publishing Service, Canberra, Australia.
112.Turpin, T., Garrett-Jones, S., Rankin, N., and Aylward, D., (1996b), *Pattern of research Activity in Australian Universities, Phase One: Final Report*, National Board of Education Employment and Training Commissioned Report No. 47, July 1996. Australian Government Publishing Service, Canberra, Australia.
113.Turpin, T., Sullivan, N., and Deville, A., (1993a), *Crossing Innovation Boundaries: The formation and maintenance of research links between industries and universities in Australia*, National Board of Education Employment and Training, Commissioned Report No.26, Volume 1, Australian Government Publishing Service, Canberra, Australia.
114.Turpin, T., Sullivan, N., and Deville, A., (1993b), *Crossing Innovation Boundaries: The formation and maintenance of research links between industries and universities in Australia*, National Board of Education Employment and Training, Commissioned Report No.26, Volume 2, Australian Government Publishing Service, Canberra, Australia.
115.Twiss, B., (1992), *Managing Technological Innovation*, Pittman Publication, London, UK.
116.Ulijn, J., et al, (2000), *Innovation, Corporate Strategy and Cultural Context: What is the mission for International Business Communication*, The Journal of Business Communication, Volume 37, Issue 3, pp. 293-316.
117.Vaughan, G., (1997), *The Future of CRC*, in a speech on Seminar of Australian Academy of Technological Sciences and Engineering, Monday, November, 24.
118.Vonortas, N., (1998), *Strategic Alliances in Information Technology and Developing Country Firms: Policy perspective,* S & T and Society, Volume 3, Number 1, pp. 181-203.
119.Waltner, C., (2000), *Knowledge Collaboration—Antidote for Information Overload—Online Software lets smaller businesses cope with floods of information*, Information Week, October 2, pp. 117-122.
120.WTIA (2000a), *Executive Summary of Ozweld, WTIA Technology Support Centre*, WTIA Secretariat, Paramatta, Sydney, Australia.
121.WTIA (2000b), *Summary of WTIA SMART TechNet Project*, WTIA Secretariat, Paramatta, Sydney, Australia.

BIBLIOGRAPHY

List of references not used directly and not quoted for the thesis.

1. Acs, Z., and Audretsch, D.B., (1990), *Innovations and Small Firms*, MIT Press, Cambridge, Mass., USA.
2. Allen, T.J., (1977), *Managing the Flow of Technology*, MIT Press, Cambridge, MA.
3. Andersen, E. S., (1994), *Evolutionary Economics*, Pinter Publications, London.
4. Anon.,(1997), *Academia-Industry-Government Relations in Biotechnology: Private, Professional and Public Dimensions of the New Associations*, Science and Public Policy, Volume 24, Number 6, pp. 421-433.
5. Bar, F., and Borrus, M., (1992), *Information Networks and Competitive Advantage: Issues for Government Policy and Corporate Strategy*, International Journal on Technology Management, Special Issue on the Strategic Management of Information and Telecommunication Technology, Volume 7, Nos. 6/7/8, pp. 398-408.
6. Barton, L. D., (1984), *Inter-personal communication patters among Swedish and Boston-area entrepreneurs*, Research Policy, 13: 101-114.
7. Betz, F., (1998), *Academic/Government/Industry Strategic Research Partnership*, Journal of Technology Transfer, Volume 22 (3), pp. 9-16.

8. Binseau, M., and Pearl, M., (1998), *The Right Mind Set of Managing Information Technology*, Harvard Business Review, September-October, pp. 119-128.
9. Bird, J., (1998), *The Dominant e-mail*, Management Today, November, pp. 81-86.
10. Bonacorssi, A., and Piccaluga, A., (1994), *A Theoretical Model of University Industry Relationship*, R & D Management 24, No. 3, pp. 229-247.
11. Bowonder, B., and Miyake, T., (1992), *A model of corporate innovation management: some recent high tech innovations in Japan*, R & D Management 22, 4, pp. 319-335.
12. Brooks, H.,(1982), *Social and Technological Innovation*, in Managing Innovation: The social dimensions of creativity, invention, and technology, Lundstedt, S.B., and Colglazier E.W., (editors), Pergamon Press.
13. Carayannis, E. G., Rogers, E. M., Kurihara, K., and Allbritton, M., (1998), *High Technology Spin-Offs from Government R & D Laboratories and Research Universities*, Technovation, Volume 18, Number 1, pp. 1-11.
14. Cohen, L., McAuley, J., Duberley, J., (2001), *Continuity in discontinuity: Changing discourses of science in a market economy*, Science, Technology and Human Values, Volume 26, Issue 2, pp. 145-166.
15. Collinson, S., (1997), *Knowledge Integration for Innovation: Comparing Multimedia Product Development at Sony and Phillips*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
16. Cordey-Hayes, M, Gilbert, M., Trott, P., (1997), *Knowledge Assimilation and Learning Organisation*s in Knowledge, Technology and Innovative Organisation, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
17. Cortese, A., (1995), *Networked Corporation*, Business Week, New York, June 26, pp 87-98.
18. Dodgson, M., (1993), *Technological collaboration in industry: Strategy, Policy and Internationalisation in Innovation*, Routledge, London, UK.
19. Dodgson, M., (1996), *Learning, Trust and Interfirm Technological Linkages: Some Theoretical Associations*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V., (editors), Edward Elgar Publishing Company, Cheltenham, UK.
20. Dosi, G. and Nelson, R.R. (2000), *Evolutionary Theory in Economics*, in Dosi's Selected Papers on Innovation, Organisation and Economic Dynamic, Edward Elgar Publishing, Aldershot, UK.
21. Dosi, G., (2000), *Corporate Organisation, Finance and Innovation*, in Dosi's Selected Papers on Innovation, Organisation and Economic Dynamic, Edward Elgar Publishing, Aldershot, UK.
22. Dosi, G., (2000), *The Research on Innovation*, in Dosi's Selected Papers on Innovation, Organisation and Economic Dynamic, Edward Elgar Publishing, Aldershot, UK.
23. Dosi, G., and Egidi, M., (2000), *Substantive and Procedural Uncertainty*, in Dosi's Selected Papers on Innovation, Organisation and Economic Dynamic, Edward Elgar Publishing, Aldershot, UK.
24. Dosi, G., Silverberg, G., and Orsenigo, L., (2000), *Innovation, Diversity and Diffusion*, in Dosi's Selected Papers on Innovation, Organisation and Economic Dynamic, Edward Elgar Publishing, Aldershot, UK.
25. Dreachslin, J. L., (1998), *Information Technology and Quality Improvement*, International Journal on Technology Management, Special Issue on Management of Technology in Health Care, Volume 15, Nos. 3/4/5, pp. 237-255.
26. Duinen, R. J. van (1998), *European Research Councils and Triple Helix*, Science and Public Policy, Volume 26, number 6, pp. 381-386.
27. Engelbrecht, H.J., (1992), *New Perspective on Inter-Sectoral Relationship Between Manufacturing and Services*, Economics and Planning 25, pp. 165-178.
28. Engelbrecht, H.J., (1997), *The International Economy, Knowledge Flows and Information Activities* in The New Research Frontiers of Communication Policy, Lamberton, D.M., (editor), Elsevier, Amsterdam, The Netherlands.
29. Ettlie, J., (1986), *Implementing Manufacturing Technologies: Lessons from Experience*, in Managing Technological Innovation, Davis, D. Donald, and Associates (editors), pp. 72-104, Jossey-Bass, San Francisco, USA.

30. Etzkowitz, H., (1997), *The Entreprenual University and The Emergence of Democratic Corporatism*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
31. Etzkowitz, H., (1997), *The Triple Helix: a North American environment*, available at http://www.hefce.ac.uk/pubs/hefce/1998/98_70.htm retrieved at July 14, 1998.
32. Etzkowitz, H., Mello, J. M. C., and Terra, B.R.C., (1998*), When Path Dependencies Collide: the Evolution of Innovation Policy in State of Rio de Janeiro, Brazil.*, Science and Public Policy, Volume 26, number 6, pp. 365-371.
33. Faulkner, W., (1995), *Getting Behind Industry-Public Sector Research Linkages: A Novel Research Design*, Science and Public Policy, Volume 22, Number 5, pp. 282-294.
34. Foray, D., and Gibbons, M., (1996), *Discovery in the context of application*, Technology Forecasting and Social Change, 53, pp. 263-277.
35. Foray, D., and Lundvall, B.A., (1996), *The Knowledge Based Economy: From the Economics of Knowledge to Learning Economy*, in OECD, Employment and Growth in the Knowledge Based Economy, pp.157-180, OECD, Paris, France.
36. Fouts, P., and Brown, W.B., (1997), *Strategy and Technology:Forming Patterns of External Relationship*, in Proceedings of PICMET'97, Kocaoglu, D.F., and Anderson, T.R., (editors.), Portland, July 27-31, pp. 15-18.
37. Fujigaki, Y., and Nagata, A., (1998), *Concept Evolution in Science and Technology Policy: the Process of Change in Relationships among University, Industry and Government*, Science and Public Policy, Volume 26, number 6, pp. 387-395.
38. Garrett Jones, S., Rankin, N., and Turpin, T., (1997), *Bricoleurs and Boundary riders: Managing basic research and innovation knowledge networks*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
39. Goldman, S.L., Nagel, R.N., and Preiss, K., (1995), *Agile Competitors and Virtual Organizations*, Van Rostrand Reinhold, New York, USA.
40. Gulbrandsen, M., (1997), *University and Industrial Competitive Advantage*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
41. Hauptmann, O., (1986), *Influence of Task Type on the Relationship between Communication and Performance: the Case of Software Development,* R & D Management, Volume 16, 2, 1986.
42. Hill, M. W., (1982), *Information for Innovation, A View from The UK*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
43. Hislop, D., Newell, S., Scarbrough, H., and Swan, J., (2000), *Networks, Knowledge and Power: Decision Making, Politics and the Process of Innovation*, Technology Analysis and Strategic Management, Volume 12, Issue 3, pp. 399-411.
44. Holthouse, D., (1998), *Knowledge Research Issues*, California Management Review, Volume 40, Number 3, pp. 277-280.
45. Imai, K., Ikujiro, N., and Takeuchi, H., (1985), *Managing the New Product Development Process : How the Japanese Companies Learn and Unlearn*, in The Uneasy Alliance: Managing the Productivity-Technology Dilemma, Hayes, R.H., Clark, K., and Lorenz (editors), pp. 337-375, Harvard Business School Press, Boston, USA.
46. Jacob, M., (1997), *Life in Triple Helix, The Contract Researchers, The University and The Knowledge Society*, Science Studies, Volume 10, Number 2, pp. 35-49.
47. Johnston, R and Gibbons, M., (1975), *Characteristics of Information Usage in Technological Innovation*, IEEE Transaction on Engineering Management, Volume 22, 1, 1975.
48. Katz, R., and Allen, T.J., (1982), *Investigating the Not Invented Here (NIH) Syndrome: A look at the Performance, Tenure and Communication Patterns of 50 R & D Project Groups*, R & D Management, Volume 12, 1.

49. Konsynski, B. R., (1993), *Strategic Control in the Extended Enterprise*, IBM Systems Journal, Volume 32, No. 1, pp. 111 – 142.
50. Konsynski, B. R., and McFarlan, E. W., (1990). *Information Partnerships - Shared Data, Shared Scale*, Harvard Business Review, September-October, pp. 114-120.
51. Kuhn, T. S., (1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, USA.
52. Kumar, K. and van Dissel, H. G., (1996), *Sustainable Collaboration: Managing Conflict and Cooperation in Interorganizational Systems*, Management of Information System Quarterly, Volume 20, No. 3, pp. 279-300.
53. Kumar, L., and Crook, C., (1999), *A Multi Disciplinary Framework of the Management of Inter-organisational Systems*, Database for Advances in Information System, Volume 30, Issue 1, pp. 22-37.
54. Lamberton, D., (1971), *Economics of Information and Knowledge*, Penguin, Harmondsworth, UK.
55. Laredo, P., and Mustar, P., (1996), *The Techno Economic Network: A Socioeconomic Approach to State Intervention in Innovation*, in Technological Collaboration: The Dynamics of Cooperation in Industrial Innovation, Coombs, R., Richards, A., Saviotti, P.P., and Walsh, V.,(editors), Edward Elgar Publishing Company, Cheltenham UK.
56. Lee, D.M.S., (1994), *Social Ties, Task-related Communication and First Job Performance of Young Engineers*, Journal of Engineering and Technology Management, Volume 11, pp. 203-288.
57. Leoncini, R., (1997), *A Model of Science and Technology Relationship*, Science and Public Policy, Volume 24, number 5, pp. 337-346.
58. Leydesdorff, L., (1997), *The New Communication Regime of University-Industry-Government Relations*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
59. Link, A. N., (1998), *The US Display Consortium, Analysis of Public/Private Partnership*, Industry and Innovation, Volume 5, Number 1, pp. 35-50.
60. Linton, J. D., (2000), *The role of relationship and reciprocity in implementation of process innovation*, Engineering Management Journal, Volume 12, Issue 3, pp. 34-38.
61. Macdonald, D., (1998), *Public Sector Industrial Relations Under the Howard Government*, Labour and Industry, Volume 9, No.2, pp. 43-59.
62. Mansfield, E and Lee, J. Y., (1997), *The Modern University: Contributor to Industrial Innovation and Recipient of Industrial R & D Support*, Research Policy 25, pp. 1047-1058.
63. Martin, B.,(1997), *Telecommunication and Management: The Knowledge Dimension*, in The New Research Frontiers of Communication Policy, Lamberton, D.M., (editor), Elsevier, Amsterdam, The Netherlands.
64. Martin, P., (1982), *The Innovative Process and the On-line Information Channels*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
65. Matthew, J., (1996), *Organisational Foundations of the Knowledge Based Economy*, in OECD, Employment and Growth in the Knowledge Based Economy, pp.157-180, OECD, Paris, France.
66. McKelvey, M. D., (1997), *Emerging Environment in Biotechnology*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
67. Means, G, E., and Faulkner, M., (2000), *Strategic Innovation in the New Economy*, Journal of Business Strategy, Volume 1, Issue 3, pp. 25-33.
68. Millar, J., Demaid, A., and Quintas, P., (1997), *Trans-Organisational Innovation: A Framework for Research*, Technology Analysis and Strategic Management, Volume 9, Number 4, pp. 399-418.
69. Mitchel, W., and Singh, K., (1996), *Survival of businesses using collaborative relationships to commercialise complex goods*, Strategic Management Journal, 17:169-195.

70. Nelson, R., and Winter, S., (1986), *An Evolutionary Theory of Economic Change*, Cambridge, MA, USA.
71. Nightingale, P., (1997*), Transfer of tacit knowledge: case study from pharmaceutical industry*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
72. Nonaka, I., (1990), *Redundant, Overlapping Organisation: A Japanese Approach to Managing the Innovation Process*, California Management review, 32(3):27-28.
73. Nonaka, I., and Takeuchi, H., (1995), *The Knowledge Creating Company*, Oxford University Press, UK.
74. Nurharyoko, G., (2001), *The Role of the Information System in Government Support for R & D Program, Case Study: CRC for Quality Wheat*, paper presented at International Symposium on Academy of International Business in South East Asia Region, Jakarta, Indonesia, 4 - 6 July.
75. Papanastassiou, M., and Pearce, R., (1997), *R & D Networks and Innovation:Decentralised Product Development in Multinational Enterprises*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
76. Parker, P., (2001), *Local-global Partnership for High-Tech Development: Integrating top-down and bottom-up models*, Economic Development Quarterly, Volume 15, Issue 2, pp. 149-167.
77. Peters , L., Groenewegen, P., Febelkorn, N., (1998), *A Comparison of Networks Between Industry and Public Sector Research in Materials Technology and Biotechnology*, Research Policy 27, pp. 255-271.
78. Powell, W.W., Koput, K.W., and Smith-Doerr, (1996), *Inter organisational collaboration and the locus of innovation: Networks of Learning in Biotechnology*, Administrative Science Quarterly, volume 41:116-145.
79. Prabu, G. N., (1997), *Knowledge Building in Industrial Firm-Technology Institution Joint R & D project: A Process Model*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
80. Prevetite, J., (1999), *Internet Advertising: An assessment of consumer attitudes*, Prometheus, Volume 17, No.2, pp. 199-209.
81. Pyka, A., (1997), *Informal Networking*, Technovation, Volume 17, number 4, pp. 207-220.
82. R & D, Innovation and Competitiveness, Bureau of Industry Economics, Research Report 50, 1993. Australian Government Publishing Service, Canberra, Australia.
83. Raisinghani, M.S., (2000), *Knowledge Management: A Cognitive Perspective on Business and Education*, American Business Review, Volume 18, Issue 2, pp. 105-112.
84. Ray, T., and Buisseret, T., (1995), *Japan's use of collaborative research to build a computer industry: lesson for the UK*, Prometheu*s*, Volume 13, Number 1, pp. 90-106.
85. Reger, G., Buhrer, S., Balthasar, A., and Battig, C., (1998), *Influence of Non Membership of the European Union on Collaboration in European R & D Networks : The Case of Switzerland*, Science and Public Policy, Volume 25, number 3, pp. 171-183.
86. Richardson, G.B., (1972), *The Organisation of Industry*, Economic Journal, 82:883-896.
87. Robey, D., and Sales, C.A., (1994), *Designing Organizations*, (4th edition), Richard Irwin, Homewood IL, USA.
88. Rogers, E.M., and Larsen J.K., (1984), *Silicon Valley Fever: Growth of High Technology Culture*, Basic Books, New York, USA.
89. Rothwell, R., (1992), *Successful Industrial Innovation: Critical Factors for 1990s*, R & D Management, Volume 22, 3:221-239.
90. Russell, S., and Williams, R., (2000), *Social Shaping of Technology: Frameworks, Findings and Implications for Policy, in Final Report European Union,* COSTA 4 Focussed Study on the Social Shaping of Technology, COST-STY-98-4018, April.
91. Sampler, J. L., (1998), *Redefining Industry Structure for The Information Age*, Strategic Management Journal, Volume 19, pp. 343-355.
92. Sheehan, P.J., Papas, N., Tikhomirova, G., and Sinclair, P., (1995), *Australia and the knowledge economy, an assessment of enhanced economic growth through science and technology*, Victoria University of

Technology, Melbourne, pp. 231 in Tegart, W.J.Mc.G., Australian Academy of Technological Sciences and Engineering-Focus No. 110- January/February 2000.

93. Shinn, T., (1997), *The emergence of Research-Technology Communities*, in University and the Global Knowledge Economy, A Triple Helix of University-Industry-Government Relations, Leydesdorff, L., and Etzkowitz, H., (editors), Cassell, London, UK.
94. Stephan, P., Audretsch D., Hawkins, R., (2000), *The Knowledge Production Function: Lesson from Biotechnology*, International Journal on Technology Management, Volume 19, Nos. 1/2, pp. 165-178.
95. Swamm, P.G.M, (1997), *Technological Change*, in The New Research Frontiers of Communication Policy, Lamberton, D.M., (editor), Elsevier, Amsterdam, The Netherlands.
96. Tassone, L., (1997), *Inter-institutional Cooperation in Research. The Efficiency of the Public Participation*, in Knowledge, Technology and Innovative Organisations, Butler, J., and Piccalugga A., (editors), Economia di Impressa, Milano, Italy.
97. Tijssen, R., and Korevaar, J.C., (1997), *Unravelling the Cognitive and Inter organisational Structure of Public/Private R & D Networks: A Case Study of Catalysis Research in The Netherlands*, Research Policy 25, pp.1277-1293.
98. Treille, J-M., (1982), *Economic Information as An Aid to Innovation: Some Orientations for Decision Support Systems Applied to Private and Government Organisations*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.
99. Trends and patterns of Public Support to Industry in the OECD area (1998), STI Review No.21, OECD.
100. Uhlin, A., Rangnes, J., and Synnevag, M. C., (2000), *Modelling and Facilitating Prospective Innovation Systems,* Paper from Third International Conference on Triple Helix, "The Endless Transition", Rio de Janeiro, Brazil, 26-29 April.
101. Wilde, D.U., (1982), *Scientific Information as An Aid to Innovation*, in Information and Innovation: proceedings of a seminar of ICSU-AB on The Role of Information in the Innovative Process, Amsterdam, the Netherlands, 24-25 May 1982, Stern, B. T., (editor), Volume 1, North Holland Publishing Company, Amsterdam, The Netherlands.

APPENDIX 1. LIST OF INTERVIEWEES.

Name	Position and Organization	Affiliated CRC	Date of interview
Dr. John Boyd	Member of CRC Committee, Department for Industry, Science and Tourism	-	October 22, 1999.
Dr.Geoffrey Vaughan	Member of CRC Secretariat, DIST	-	June 9, 1999
Dr. William Rathmell	CEO CRC QW	CRC QW	November 29, 1999
Ms.Di Miskelly	Program leader project number 3A, CSIRO Plant Industry	CRC QW	November 11, 1999
Prof.John Lovett	Executive Director, GRDC and member of CRC QW Board of Directors.	CRC QW	February 4, 2000
Prof.Roger Tanner	PN Russell Professor, UoS and member of CRC QW Board of Directors.	CRC QW	February 8, 2000
Dr.Dai Suter	Director George Weston Food Laboratory and member of CRC QW Board of Directors.	CRC QW	February 10, 2000
Dr. John Huppatz	Ass.Chief, CSIRO Plant Industry and member of CRC QW Board of Directors.	CRC QW	February 7, 2000
Dr. Ferenc Bekes	Chief Program 5, Bread Research Institute Ltd.	CRC QW	October 5, 2000
Mr.Christopher Smallbone	Executive Director, WTIA and member of CRC WS Board of Directors.	CRC WS	March 8, 2000
idem	idem	idem	September 4, 2000
Mr.Bradley Glass	PhD student, Fac.of Mechanical Engineering, University of Wollongong. Recipient of CRC scholarship and participant of CRC WS education program.	CRC WS	November 10, 1999
Dr. Colin Chipperfield	Chief Executive Officer CRC for Welded Structures	CRC WS	June 24,2000
Dr. Adam Jostsons	Director, ANSTO Material Division and member of CRC WS Board of Directors.	CRC WS	June 1, 2000
Dr. Allen Beasley	Executive Director, Australian Pipeline Industry Association and member of CRC WS Board of Directors.	CRC WS	October 25, 2000
Dr. Frank Barbaro	Chief, BHP Integrated Steel Division	CRC WS	October 4,2000
Mr.Peter Milne	Program Leader for Data Mining Project, CMIS	ACSys CRC	November 9, 1999
Dr.Graham Reynolds	Program Leader for Digital Media Library Project, CMIS	ACSys CRC	November 18, 1999

Continued on the next page

Name	Position and Organization	Affiliated CRC	Date of interview
Mr. Andy Wyatt	Director, Business Development, Silicon Graphics Institute Australia and member of ACSys CRC Board of Directors.	ACSys CRC	March 16, 2000
Mr. Bob Mounic	Director, Business Development System, Sun Microsystem Australia and member of ACSys CRC Board of Directors.	ACSys CRC	March 17, 2000
Dr. John O'Callaghan	CEO ACSys CRC	ACSys CRC	November 30, 1999
Mr. Greg Mc.Cane	Executive Director, Digital Equipment Corporation Australia and member of ACSys CRC Board of Directors.	ACSys CRC	March 29, 2000

APPENDIX 2. WTIA TECHNICAL PANELS AND THE WTIA SMART PROGRAM.

WTIA TECHNICAL PANELS (Source: Summary of WTIA SMART Technet Project, 2000).

Please see print copy for Appendix 2

THE SMART TECHNET PROGRAM (Source: WTIA ,2000b).

Please see print copy for Table A.2.1

Table A.2.1. WTIA SMART Tech Net Program. Source WTIA (2000b).

APPENDIX 3. LIST OF OPERATIONAL CRC, AS OF NOVEMBER 2001.
(Source: http://www.dist.gov.au/crc/centres/index.html, retrieved at November 11, 2001).

CRC selection rounds are held approximately every two years. Rounds were held in 1990, 1991, 1992, 1994, 1996, 1998 and 2000. The 2002 Selection round was announced by the Minister on 3 October 2001. Of the 64 CRCs currently supported under the CRC Program, 12 are in the Manufacturing Technology sector, 7 in the Information and Communication Technology sector, 8 in the Mining and Energy sector, 12 in the Agricultural and Rural Based Manufacturing Sector, 15 in the Environment sector, and 10 in the Medical Science and Technology Sector.
(Source: http://www.dist.gov.au/crc/2002_Selection_Round/index.html, retrieved at November 11, 2001)

Sector: Manufacturing Technology.

1. CRC for Advanced Composite Structures.
2. CRC for Bioproducts.
3. CRC for CAST Metals Manufacturing (CASTMM).
4. CRC for Construction Innovation.
5. CRC for Functional Communication Surfaces.
6. CRC for Innovative Wood Manufacturing.
7. CRC for Intelligent Manufacturing Systems and Technologies.
8. CRC for International Food Manufacture and Packaging Science.
9. CRC for MicroTechnology.
10. CRC for Polymers.
11. CRC for Railway Engineering and Technologies.
12. CRC for Welded Structures.

Sector: Information and Communication Technology.

1. CRC for Enterprise Distributed Systems Technology.
2. Australian Photonics CRC.
3. CRC for Satellite Systems.
4. CRC for Sensor Signal and Information Processing.
5. CRC for Smart Internet Technology.
6. CRC for Technology Enabled Capital Markets.
7. Australian Telecommunications CRC.

Sector: Mining and Energy.

1. AJ Parker CRC for Hydrometallurgy.
2. CRC for Coal in Sustainable Development.
3. CRC for Clean Power from Lignite.
4. CRC for Landscape Environments and Mineral Exploration.
5. CRC for Mining Technology and Equipment.
6. Australian Petroleum CRC.
7. CRC for Predictive Mineral Discovery.
8. Australian CRC for Renewable Energy.

Sector: Agriculture and Rural Based Manufacturing.

1. Australian Cotton CRC.
2. CRC for Australian Sheep Industry.
3. CRC for the Cattle and Beef Quality.

4. CRC for Innovative Dairy Products.
5. CRC for Molecular Plant Breeding.
6. CRC for Sustainable Aquaculture of Finfish.
7. CRC for Sustainable Production Forestry.
8. CRC for Sustainable Rice Production.
9. CRC for Sustainable Sugar Production.
10. CRC for Tropical Plant Protection.
11. CRC for Value Added Wheat (*new name for CRC for Quality Wheat as of October 2001)*
12. CRC for Viticulture.

Sector: Environment.

1. CRC for Antarctica and the Southern Ocean.
2. CRC for Australian Weed Management.
3. CRC for Biological Control of Pest Animals.
4. CRC for Catchment Hydrology.
5. CRC for Coastal Zone, Estuary and Waterway Management.
6. CRC for Conservation and Management of Marsupials.
7. CRC for Freshwater Ecology.
8. CRC for Greenhouse Accounting.
9. CRC for Plant-based Management of Dryland Salinity.
10. CRC for Sustainable Tourism.
11. CRC for The Great Barrier Reef World Heritage Area.
12. CRC for Tropical Rainforest Ecology and Management.
13. CRC for Tropical Savannas Management.
14. CRC for Waste Management and Pollution Control.
15. CRC for Water Quality and Treatment.

Sector: Medical Science and Technology.

1. CRC for Aboriginal and Tropical Health.
2. CRC for Asthma.
3. CRC for Cellular Growth Factors.
4. CRC for Chronic Inflammatory Diseases.
5. CRC for Cochlear Implant and Hearing Aid Innovation.
6. CRC for Diagnostics.
7. CRC for Discovery of Genes for Common Human Diseases.
8. CRC for Eye Research and Technology.
9. CRC for Tissue Growth and Repair.
10. CRC for Vaccine Technology.

APPENDIX 4. LIST OF OPERATIONAL CRC, AS OF JUNE 2005.

(Source: https://www.crc.gov.au/Information retrieved at June 14, 2005).

The CRC program continues to grow strongly. The following lists the operational CRCs as of June 2005.

Sector: Manufacturing Technology

1. CRC for Advanced Composite Structures
2. CRC for Bioproducts
3. CRC for CAST Metals Manufacturing (CAST)
4. CRC for Construction Innovation
5. CRC for Functional Communication Surfaces
6. CRC for Wood Innovations
7. CRC for Intelligent Manufacturing Systems and Technologies
8. CRC for Micro Technology
9. CRC for Polymers
10. CRC for Railway Engineering and Technologies
11. CRC for Welded Structures

Sector: Information and Communication Technology

1. Australian Photonics CRC
2. Australian Telecommunications CRC
3. CRC for Enterprises Distributed Systems Technology
4. CRC for Satellite Systems
5. CRC for Sensor Signal and Information Processing
6. CRC for Smart Internet Technology
7. CRC for Spatial Information
8. CRC for Technology Enabled Capital Markets
9. Australasian CRC for Interaction Design
10. CRC for Integrated Engineering Asset Management

Sector: Mining and Energy

1. AJ Parker CRC for Hydrometallurgy
2. CRC for Clean Power from Lignite
3. CRC for Coal in Sustainable Development
4. CRC for Landscape Environments and Mineral Exploration
5. CRC for Predictive Mineral Discovery
6. CRC for Sustainable Resources Processing
7. CRC for Greenhouse Gas Technologies
8. CRC for Mining

Sector Agriculture and Rural Based Manufacturing

1. Australian Cotton CRC
2. CRC for Australian Sheep Industry
3. CRC for Cattle and Beef Quality
4. CRC for Innovative Dairy Products
5. Molecular Plant Breeding CRC
6. CRC for Sustainable Aquaculture for Finfish

7. CRC for Sustainable Production of Forestry
8. CRC for Sustainable Rice Production
9. CRC for Tropical Plant Protection
10. CRC for Value Added Wheat
11. CRC for Viticulture
12. CRC for Australian Biosecurity: Emerging Infectious Diseases (ABC:EID)
13. Australian Poultry CRC
14. CRC for Innovative Grain Food Products
15. CRC for Sugar Industry Innovation through Biotechnology

Sector: Environment

1. CRC for Australian Weed Management
2. CRC for Biological Control of Pest Animals
3. CRC for Catchment Hydrology
4. CRC for Coastal Zone, Estuary and Waterway Management
5. CRC for Freshwater Ecology
6. CRC for The Great Barrier Reef World Heritage Area
7. CRC for Greenhouse Accounting
8. CRC for Plant-based Management of Dryland Salinity
9. CRC for Sustainable Tourism
10. CRC for Tropical Rainforest Ecology and Management
11. CRC for Tropical Savannah Management
12. Environmental Biotechnology CRC
13. CRC for Water Quality and Treatment
14. Desert Knowledge CRC
15. Bushfire CRC
16. CRC for Irrigation Futures
17. CRC for The Antarctic Climate and Ecosystems
18. CRC for Landscape Environments and Mineral Exploration

Sector: Medical Science and Technology

1. CRC for Aboriginal Health
2. CRC for Asthma
3. CRC for Chronic Inflammatory Diseases
4. CRC for Cochlear Implant and Hearing Aid Innovation
5. CRC for Diagnostics
6. The Vision CRC
7. CRC for Vaccine Technology

APPENDIX 5. THE CONDITION FOR RENEWED FUNDING OF CRC

(Source: CRC Program, Selection Rounds 2004, Guidelines for Applicants taken from https://www.crc.gov.au/about retrieved at June 14, 2005).

Requirements for applications for 'new from existing' CRCs according to the CRC Guidelines sections 2.4.1 and 2.4.2 are as follows (Ref.: CRC Program, Selection Rounds 2004, Guidelines for Applicants page 6 taken from https://www.crc.gov.au/about retrieved at June 14, 2005**)**

"For 'new from existing' CRC applications, elements of the proposed research programme that are effectively a continuation of existing projects must be identified and justified in the Preliminary Business Case (Stage 1), and transitional arrangements into the new CRC must be provided in Stage 2."

"The CRC Committee will exercise its judgement as to what constitutes a 'new from existing' application. The Committee may take note of any research projects that are effectively a continuation of existing projects and the extent of changes in participants. Applicants may be required to lodge a Stage 2 application as a 'new from existing' CRC even if the Stage 1 application was not lodged on that basis."

"'New from existing' applicants must use the same application form as for new CRCs but must clearly indicate that it is a 'new from existing' application and address the additional issues which the CRC Committee will consider."

Moreover from section 2.5.1 CRC guidelines 2004, the following general criteria has to be met for a CRC application to be granted: (Ref.: CRC Program, Selection Rounds 2004, Guidelines for Applicants page 6, taken from https://www.crc.gov.au/about retrieved at June 14, 2005)

1. "The outcomes will contribute substantially to Australia's industrial, commercial and economic growth.
2. The path to adoption (commercialisation/utilisation) will achieve the identified outcomes.
3. The collaboration has the capability to achieve the intended results.
4. The funding sought will generate a return and represents good value for the taxpayer."

The more specific conditions that have to met for a CRC to get its funding renewed are divided in the so called stage-1 (preliminary business case) and stage-2 (full business case) which will be explained below.

Stage-1 Preliminary Business (Ref.: CRC Program, Selection Rounds 2004, Guidelines for Applicants page 5 to page 10, taken from https://www.crc.gov.au/about retrieved at June 14, 2005)

"Selection criterion 1 – The outcomes will contribute substantially to Australia's industrial, commercial and economic growth."

"The CRC Committee will consider, among other things, whether the outcomes have the potential to make a substantial contribution to Australia's industrial, commercial and economic growth; whether the outcomes have the potential to contribute to National Research Priority goals; and whether the outcomes are likely to meet demonstrated need(s) or opportunities."

"For 'new from existing' applicants, the CRC Committee will also consider whether the outcomes are substantially different from or additional to those which the existing CRC should have achieved."

"Selection criterion 2 – The path to adoption (commercialisation/utilisation) will achieve the identified outcomes."

"The CRC Committee will consider, among other things, whether the strategies for the path to adoption are appropriate to achieve the outcomes and to the end-user environment and the number and significance of the end-user participants."

"Selection criterion 3 – The collaboration has the capability to achieve the intended results"

"For 'new from existing' applicants, the CRC Committee will also consider evidence provided of the track record of the existing CRC in collaboration and achieving intended results."

"For 'new from existing' applicants, the CRC Committee will also consider whether any elements of the proposed research programme that are effectively a continuation of existing projects have been identified and justified."

"Selection criterion 4 – The funding sought will generate a return and represents good value for the taxpayer"

"The CRC Committee will consider, among other things, the extent of resources from private sector and public sector participants; and the appropriateness of the amount of CRC Programme funding sought."

Stage 2- Full Business Case

"The purpose of the Full Business Case is to present a convincing case to the CRC Committee that the application should be funded in competition with all other applications."

"Applications from 'new from existing' CRCs need to include in their application strategies that would be used (if the application were to be successful) to manage the transition between the existing CRC and the new CRC. These strategies should cover completion of the current research and commercialisation/utilisation activities, wind-up arrangements and financial arrangements reflecting termination of Commonwealth funding for the existing CRC at 30 June 2005. Arrangements to deal with residual staff entitlements should also be included."

"Selection criterion 1 – The outcomes will contribute substantially to Australia's industrial, commercial and economic growth"

"The CRC Committee will consider, among other things, the scale of the outcomes and robustness of the estimation of the scale of the outcomes. Outcomes may include, but are not limited to, additional economic activity, benefits to a number of businesses through cost savings, new and improved goods and services, creation of new jobs, improved sustainability of existing businesses or industry sectors, and improved capability in firms/industry sectors to identify, adopt and adapt technologies."

"Applicants should note that business cases that rely solely on public benefit outcomes are unlikely to be competitive."

"The CRC Committee will consider the extent of the contribution of the outcomes to the National Research Priority goals. Applications that make a substantial contribution will be ranked more highly on this criterion than those that make little or no contribution."

Selection criterion 2 – The path to adoption (commercialisation/utilisation) will achieve the identified outcomes

"The CRC Committee will consider, among other things, the robustness of the assessment of market or other end-use opportunities; the quality of the planning and proposed resourcing (including any use of external expertise) for the commercialisation/utilisation strategies, including communication activities; the adequacy of intellectual property management arrangements; the strength of commitments by end-user participants, including through international collaborations, and any strategies to engage additional end-users during the life of the CRC."

"The CRC Committee will consider the approach for engaging small to medium sized enterprise (SME) end-users in the CRC. (SMEs are defined as firms or businesses that employ up to 200 staff.)"

"Selection criterion 3 – The collaboration has the capability to achieve the intended results"

"For 'new from existing' applicants, the CRC Committee will consider the track record of the existing CRC. Such applicants will need to include in their Full Business Case evidence from an independent review of the existing CRC's achievements to support their claims."

"Selection criterion 4 – The funding sought will generate a return and represents good value for the taxpayer"

"The CRC Committee will consider, among other things, the return on investment including the value of the proposed outcomes relative to the costs and the appropriateness of the budget and resource allocations."

APPENDIX 6 THE CRC MWJ TO THE CRC WS

"In the fiscal year 1998/99, the CRC-MWJ changed its name to the Co-operative Research Centre for Welded Structures (CRC-WS). Unlike the CRC MWJ, which was mainly focused on generic welding technologies identified by researchers and which initially had limited industry support the research plan for the CRC WS is entirely based on the need of users and has high level of support from them. It carefully integrates into a balanced program of strategic longer term and short term tactical research, the competences of the core partners in research and technology transfer with the real needs of industry". (CRC WS 1999-2007:p 1)