Business and University Relationships

The nature and extent of advanced manufacturing links and university-industry linkages

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Summary

Knowledge is now being viewed as the key for the competitiveness of both a region and a business. It plays a critical part in the innovation process, national economic growth and regional economic development. This thesis involves two interrelated components investigating the nature of business links in different advanced manufacturing regions in Adelaide and the nature of university-industry links for three South Australian universities.

The study focuses on two case studies, with the first case study based around Flinders University and the University of Adelaide. The second case study involves two advanced manufacturing regions, north and south of the Adelaide Central Business District. The primary aims of the study is to understand the range of university-industry links and how university academics interact with different industry partners, and understanding the scope of small advanced manufacturing clusters and how businesses within theses clusters interact with other businesses and organisation.

This study has reviewed the literature on clusters and university-industry links to develop and apply a framework to investigate the different relationships. Through a process of identifying and understanding the characteristics of university-industry links, the type of links, nature of collaborating partners and benefits can be analysed to determine if there is difference in these due to the different alignment of universities. By determining the different relationships in a cluster, the effect of location can be determined which then allows for classification of the cluster. Finally, this study has contributed knowledge to research areas of clusters and university-industry links.

Declaration

I certify that this thesis does not include any material previously submitted for a degree or diploma in any university without acknowledgment. To the best of my knowledge and belief this thesis does not contain any material previously published or written by another person without due acknowledgment in the main text and bibliography of the thesis.

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Paul Felici

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Date

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Abbreviations

ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industry Classification
ARC	Australian Research Council
ATN	Australian Technology Network
BERD	Business Expenditure on R&D
COA	Commonwealth of Australia
CBD	Central Business District
CRC	Co-operative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEST	Department of Education, Science and Technology
DSTO	Defence Science and Technology Organisation
GDP	Gross Domestic Product
GERD	General Expenditure on R&D
Go8	Group of Eight Universities
HECS	Higher Education Contribution Scheme
HERD	Higher Education Expenditure on R&D
IRU	Innovative Research Universities Australia
NIS	National Innovation System
NGU	New Generation Universities
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SME	Small to Medium Enterprise
USA	United States of America

Chapter One

Introduction

1.1 Introduction

This thesis studies the nature and extent of different links between advanced manufacturing businesses and universities in Adelaide, South Australia. The study is divided into two sections which allows for an understanding of the links between industries (Chapter Eight) and also the links between universities and industries (Chapter Seven). The research will analyse and highlight the differences between industry links and university links, and examine the important factors including the location of these industries and the grouping and goals of the universities. In the first part of the study, the three local South Australian universities and their links with industry are investigated, while in the second part, business links in three different manufacturing regions are explained. The study is multi-disciplinary and contributes to an understanding of university-industry links, business links, knowledge and regional development.

The three local universities, Flinders University, University of Adelaide and the University of South Australia, share a number of common attributes such as geographic co-location, social and natural resource assets. They differ from each other through their different university alignments, pedigree and history. Collaboration with industry plays a major role in the dissemination of knowledge and allows for universities to receive extra funding as well accomplish their community missions. The nature and extent of these collaborations with industry, together with the opinions of academics on the advantages of these collaborations, forms the first focus for this study.

In last decade, the Australian advanced manufacturing industry has grown considerably. Businesses within this industry are significant exporters and are important generators of employment, wealth and economic growth in many regions of Australia. The industry involves established and sometimes complex business relationships and contains a significant number of small and medium enterprises as well as larger companies. The manufacturing industries within Adelaide are indicative of many manufacturing regions around Australia and have common features such as location, knowledge base, innovation levels, business collaboration and economic resources. Location and business links play a major role in the growth of advanced manufacturing businesses, and it is the nature and extent of these links with other businesses and universities that forms the second focus of this study.

1.1.1 Higher Education Sector

The higher education sector is becoming more important as Australia’s economy transforms in to a knowledge-based economy. The sector is dominated by universities, but there are also self-accredited and non-self-accredited higher education institutions. The core functions of universities are to provide teaching and the production of open basic research.

The teaching role of universities provides for the development of skilled graduates who can utilise their skills and knowledge in the workforce. If universities undertake research with industry, the utilisation of this research and subsequent technologies will yield economic benefits at a business, regional and national level.

The higher education environment is changing due to competition for students and funding and so institutions are now working within their regional context to find effective ways to the produce knowledge and skills that the region needs. As the knowledge economy expands, regional growth will be reliant on business knowledge levels and so universities play a key and critical role in the transfer of knowledge and technologies to the community, through engagement with industry, government departments and agencies and community groups.

1.1.2 The Manufacturing Industry

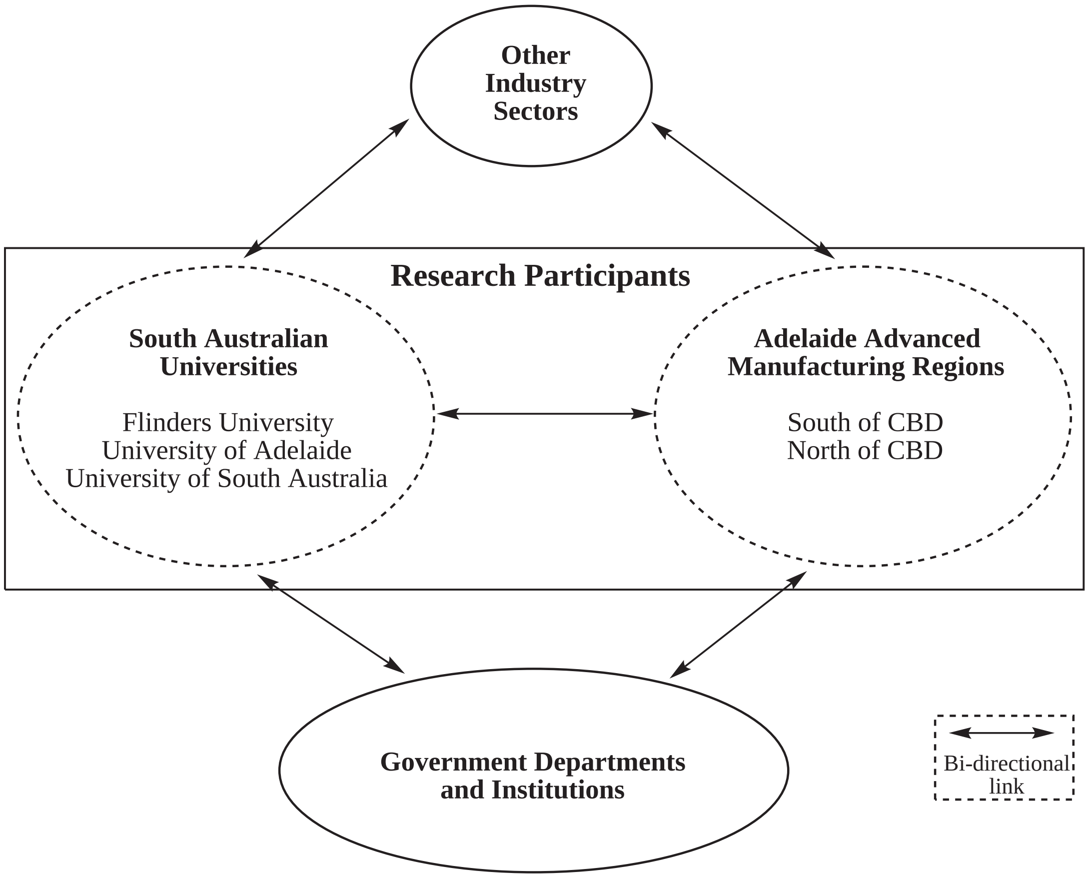
The manufacturing industry in Australia covers a wide range of industry sectors including metal product manufacturing, machinery and equipment manufacturing, petroleum and chemical manufacturing and food, beverage and tobacco manufacturing. In 2005-06 the Australian manufacturing industry accounted for 51% of total exports and generated $316 billion of sales and services income (ABS, 2008a). In recent years the influence of the manufacturing industry on Australia's economy has diminished due to international competition. The manufacturing industry contributed 10.1% of Australia's Gross Domestic Product (GDP) in 2005-06 and represented 10% of total employment in 2007 (ABS 2008a).

The advanced manufacturing industry is primarily concerned with providing designs, products and technologies to high-technology industries such as the defence, electronic, aerospace, automation, appliances and automotive industries. It represents the second largest sector of Australian manufacturing and generates exports to the United States of America (USA), Japan, Europe and the United Kingdom. This industry has developed its competitive advantage through the development of technologies and niche products as compared to other types of manufacturing, whose advantage comes through low wages and other economic conditions.

1.1.3 Study Sections

It is a combination of university-industry links and business relationships sections that will allow for an understanding of the nature and extent of key relationships in the advanced manufacturing industry and university-industry links (Figure 1.1).

Figure 1.1: Representation of the two study sections and links that are being researched.



1.2 Background to the Study

1.2.1 Clusters, Industry and Innovation

Differences between clusters and industry have been identified and described, with clusters being associated with agglomeration or co-location. Innovation is now viewed as the key for business and regional growth and can be enhanced by businesses in the same industry working together in clusters.

1.2.1.1 Clusters

Marshall (1920) theorised that firm concentrations in a particular place confer an economic advantage over firms that are not agglomerated. Marshall argued that these advantages arose from increasing returns to scale through local markets, easy diffusion of new concepts and a large local skilled labour force. Clustering goes beyond agglomeration or co-location to include the relationships that are occurring between co-located businesses. Clustered businesses generate interactions and collaborations between themselves to enhance both business growth and cluster growth. Businesses located within clusters start to recognise that their competitive advantage lies partially in their location.

Rosenfeld (1997) suggests that relationships go further than economic interactions and agglomeration within clusters; they are embedded deep into the social fabric of a industry or cluster. This implies that an understanding of these relationships is complex and plays a critical role in the economy (Porter, 1998). Relationships between businesses within small clusters usually take on different forms to those between businesses within larger and more established and recognised clusters (Rosenfeld, 1997). The evolution of each cluster will be unique and it is this uniqueness which has given rise to many different cluster theories, models and methodologies (Chapter Four). These theories, models and methodologies will reflect different research agendas and applications.

A well accepted industry cluster theory is Porter’s Diamond Factor Model of National Competitive Advantage. The theory details that the success of a country’s export firms depends on four sets of factors: firm strategy, structure and rivalry; factor input conditions; demand conditions; and related and supporting industries. This Diamond Model or competitive diamond dictates that the more developed and intense the interactions between the four factors, the greater the productivity of the firms involved (Porter, 1990).

This diamond model is deeply entrenched in the concept of local industrial clustering and Porter has promoted this concept of clusters based on these factors and determinants of competitiveness. Porter's Diamond Model and cluster concept has attracted considerable interest from politicians and policy makers due to the emphasis placed on the importance of competitiveness for succeeding in today's global economy (Martin and Sunley, 2003).

There are two key elements to Porters concept of clusters. The first is that clusters are interconnected companies and associated institutions such as universities linked by commonalities and complementarities. These links are both vertical (buying and selling chains) and horizontal (use of similar specialised inputs, complimentary services, universities, institutions and technologies). These linkages involve networks and relationships and produce benefits for the firms involved (Porter, 1998). The second element is that clusters are geographically located firms and institutions. This co-location encourages and enhances the networks and relationships between the firms and strengths the benefits of these linkages.

1.2.1.2 Industry

Industry classifications can highlight the nature and extent of a cluster, especially when they fall within a distinct division or group. The difficulty in using a classification to describe a cluster arises when an industry type falls within several different groups and classes and so it is more difficult to map. The non-conformity of classifications makes the use of clusters a relevant way to map, describe, measure and report the links between interrelated and co-located businesses. This situation was clearly demonstrated when Keeble *et al.* (1999), Sternberg & Tamásy (1999), and Longhi (1999) described the Cambridge, Munich and Sophia Antipolis high technology clusters by respectively. These descriptions involved relationships between businesses which were represented by several different industry classifications.

The Australian Bureau of Statistics (ABS) defines an industry by the Australian and New Zealand Standard Industry Classification (ANZSIC). Within the manufacturing division, the advanced manufacturing industry falls mainly within the subdivision of machinery and equipment manufacturing and within the classes of industrial machinery and equipment manufacturing (ANZSIC 2400), motor vehicle and part manufacturing (ANZSIC 2310), photographic, optical and ophthalmic equipment manufacturing (ANZSIC 2411), other professional and scientific manufacturing (ANZSIC 2419), machine tools and part manufacturing (ANZSIC 2463) and electrical equipment manufacturing (ANZSIC 2430).

1.2.1.3 Innovation

Innovation is different to pure invention (Gordon & McCann, 2005). It is about ideas and the conversion of these ideas into valuable results such as products, processes and services. The creation of new knowledge and use of that knowledge is at the heart of innovation.

Economic researchers and policy makers have identified innovation as the key to business prosperity. Porter (1998) argued that innovative capacity is the key to productivity. So the development and eventual diffusion of new technologies is crucial to increased productivity, which leads to greater prosperity. When it comes to globalisation, "productivity and innovation, not low wages, low taxes or a devalued currency, are the definition of competitiveness" (Porter, 2000).

Innovation has been linked to increased market shares, higher growth rates and greater profitability for businesses. Influences on innovation include large major economic developments such as globalisation, information and communication technologies and increasing importance of services. This emphasis on increased productivity and innovation is observed in Australia through the Federal Government's Backing Australia's Ability scheme. This is a large, highly coordinated package of measures provided to support science and innovation in this country.

Schumpter (1934) defined "radical" innovations as world changers, while "incremental" innovations are continuously filling in the process of change. Various types of innovation defined by Schumpter (1934) are:

- introduction of a new product or qualitative change in an existing product
- process innovation to a new industry

- the opening of a new market
- development of new sources of supply for raw materials or other inputs
- changes in industrial organisation

The Organisation for Economic Co-operation and Development (OECD) has released an internationally recognised standard for measurement of innovation in the Oslo Manual. The manual limits its definition of innovation to Schumpter's first two types; it identifies innovation in terms of technological product and process innovations.

The Oslo Manual is managed jointly by the OECD and the European Commission and has been developed by experts from thirty countries who collect and analyse innovation surveys. The sheer nature and complexity of the innovation process and its variations within different firms, means that the manual's guidelines are not absolutely precise but are a strong set of guidelines which are applied to produce useful data on innovation.

1.3 Research Questions

As this study has two parts there are two main aims for the study which are to examine the links between industries within a region and to assess the links that different universities undertake with industry. The two main research questions are:

> *What is the nature and extent of links that advanced manufacturing businesses undertake with other businesses, government bodies and research bodies in different regions?*

> *What is the nature and extent of links that the three South Australian universities undertake with industry?*

These main research questions require a number of secondary questions to be addressed:

What business links differ due to cluster location?

What is the views of industry in collaborating with universities and do these collaborations differ between regions?

What is the advantages for a business being located within a particular region?

Does the grouping of a university have an effect on the levels of industry links?

What is the views of academics and researchers at different universities on fundamental and applied research?

For these questions to be addressed, a number of different research areas will be investigated to understand the nature of business-business links and university-industry links, such as:

- regional characteristics
- identification of business links within different regions
- innovation activity of businesses
- South Australian university characteristics and alignment
- benefits and improvements of university-industry collaborations
- academic views on fundamental and applied research

This study involves the development of a relevant framework to analyse the above research areas. The study involves both quantitative and qualitative research which will be carried out by questionnaires and relevant secondary data.

1.4 Significance of the Study

Innovation and knowledge are increasingly becoming the keys for regional and national economic growth. These factors are supported by research and development and it is the increased research and development funding that allows businesses to develop a unique knowledge base to remain competitive in the global knowledge based economy. Knowledge can be developed through university-industry links and business relationships

There is has been limited research conducted on industry-university links within Australia and the majority of understanding comes from research conducted in the USA and Europe. This study attempts to contribute to this body of research by investigating the concept of industry-university links from the perspectives of three local universities which are aligned with different university groupings. This study of university-industry links for different universities provides an opportunity to investigate the nature of industry partners and the benefits industry and universities obtain from undertaking collaborations.

Clusters are also seen as a key aspect of economic growth. Clusters have developed internationally in different industry sectors such as biotechnology, electronics, textiles and automotive manufacturing. Cluster policies are being utilised within a national and regional context to develop regions and it is this regional economic development that attracts new businesses to the region. Porter (2002) argues that new and emerging areas of economic growth with novel and niche industry sectors occur when new clusters develop with increasing business links and collaborations with research institutions.

While Porter emphasises the importance of local networks and relationships for the production and flow of knowledge and information within the cluster, these processes are under theorised and under developed in his cluster model (Martin and Sunley, 2003). There is little investigation in his model and case study examples of these knowledge linkages between firms and institutions within these clusters.

Questions about Porters Diamond Model and cluster definitions have arisen, especially the lack of boundaries both in the geographical sense and the relationships and linkages. Such questions are:

- What are the types of linkages between firms and institutions and how strong are these linkages?
- Over what geographical range do these linkages occur and what is the knowledge spillover and movement?

These criticisms and questions of Porter's Diamond Model and cluster definition have been utilised to generate the key research areas for this thesis.

There are important aspects of cluster relationships and university-industry links that are yet to be fully researched or understood. This study aims to contribute to the research in both of these areas by investigating industry-university links for the three different South Australian universities and cluster relationships in advanced manufacturing regions of Adelaide. Studying industry-university links will identify the nature and extent of these links and factors and benefits that are important for the development of these links. This identification will also provide ways for enhancing links between industry and universities.

1.5 Research Issues

The two components of this study both involve different groups of participants. The university component involves three South Australian universities and the industry component comprises of two advanced manufacturing regions. A multidisciplinary approach will be used in the study and so it is important to clearly identify and define key terms. These definitions are specific for research in this study and so are not necessarily applicable in other research and studies.

1.5.1 Research Definitions

It is critical for the purpose of this study to have clear definitions and distinctions between industry, cluster and clustering. The term ‘industry’ can be thought of as a collection of manufacturing or technically productive enterprises of a particular type Industries are often named after their principal product, such as the steel industry, automotive industry and petroleum industry.

Enterprises belonging to industries are often not co-located and undertake relatively few collaborative activities or interaction, but undertake their particular functions in a value chain or across value chains.

The term cluster has been defined in various different ways and these definitions have been refined over time as more research is conducted in this area. The definition offered by Porter (1998) is the most widely quoted, but this definition doesn’t cover the different applications of clusters which entail a small number of businesses and in regions that are located within the same metropolitan area. The terms ‘business’ and ‘firm’ used in this study are interchangeable and are defined as a commercial enterprise or establishment that provides goods and/or services to consumers.

In this study, the terms ‘relationship’, ‘link’ and ‘collaboration’ are used and are considered to be interchangeable. The terms link or relationship are interpreted differently throughout the literature, but they usually relate to a form of activity between two or more organisations. The terms link or relationship used in this study are defined as cooperative arrangements between businesses, universities and government departments and institutions in various combinations to share knowledge and resources in pursuit of a shared specific outcome or R&D objective. This cooperative arrangement may be formal or informal. The use of the terms university-industry or industry-university links represent the same link and are not indicative of which partner is more important.

A review of the types of relationships between industry and universities is provided in Chapter Three. The concept of clusters and different types of relationships between businesses are discussed further in Chapter Four.

The definition of industry is broad and will be dependent on the industry type. Within the manufacturing industry, there is still contention of what advanced manufacturing really entails. The definition of the term for this study is wide and covers businesses and enterprises that see themselves as part of the industry. These businesses or enterprises usually have leading edge practices, technologies and organisational cultures.

This incorporates a diverse group of businesses whose industry definition is undefined as their activities are spread across several industry sectors. For example a business that makes medical devices might be classified under the ANZSIC code as being in the health sector when it should actually be defined as being in the advanced manufacturing sector. The manufacturing and advanced manufacturing sector will be discussed in more depth in Chapter Two.

1.5.2 Study Organisation

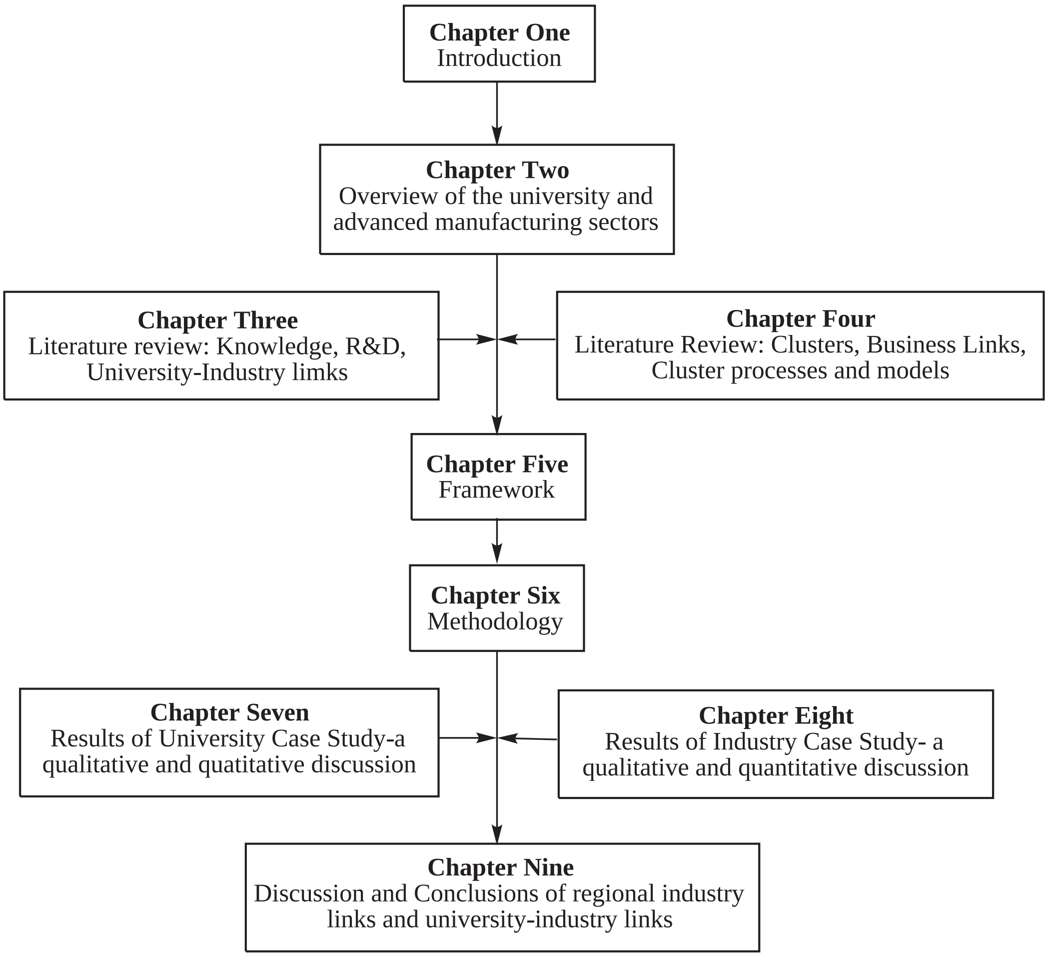
This study includes complex theories and concepts about industry location, clustering, business relationships and university-industry collaborations. A framework approach has been used to simplify these complex theories and concepts by providing a specific structure and methodology. The framework is used to identify business links occurring within each region and between each university and this allows for the determination of the nature and extent of these links. The framework also enables identification of the strengths of the industry region and the university, and the importance of these strengths for the region and the university.

As this study is investigating the nature and extent of industry-industry links and university-industry collaborations both qualitative and quantitative approaches are used. The use of primary and secondary data gathering techniques such as archival databases and questionnaires allows for comparative information to be gathered for use in a case study approach. A case study approach is being used as Yin (2003) argues that this approach allows for a certain phenomenon to be analysed in a context where the phenomenon and context are not clearly evident or defined. Chapter Six describes the case study methodology and the justification for using this approach.

1.6 Thesis Outline

The thesis consists of nine chapters which are represented in Figure 1.2.

Figure 1.2: Thesis Structure



Chapter Two provides a summary of the advanced manufacturing industry and the higher education sector. The chapter introduces the importance of the advanced manufacturing sector and discusses the different university groupings and their formation and differing characteristics. The chapter also highlights how the manufacturing sector and higher education sector contribute to the Australian economy. The chapter discusses the roles that universities play in regional development and the significance of high-technology small-medium enterprises (SMEs).

Chapter Three is an overview of university-industry collaborations and the roles knowledge and research and development play in the economy. The chapter outlines the different kinds of knowledge and highlights the role each kind takes in the new and emerging knowledge based economy. There is a discussion of R&D and how this underpins science and innovation and current Australian R&D expenditure levels. The chapter focuses in particular on the different mechanisms of university-industry links and the advantages associated with these links for each partner. It introduces the barriers that prevent industry-university links and government programs that increase them.

Chapter Four contains a description of clusters and how they differ from industry agglomerations and networks. There is a review of cluster research and its use in defining high technology clusters. The chapter highlights the clustering process and how this process can be used to understand complex relationships within these clusters as well as cluster models and methodologies. This chapter also highlights how an understanding of these relationships can define industries of limited critical mass within clusters.

Chapter Five formulates and develops a framework for the study. The framework organises the study and directs the research methodology. The framework developed ensures that the relevant aspects of clusters and university-industry links are covered in the study. The concepts that form the framework allow the framework to form the basis for correct development of the research methodology.

Chapter Six contains the research method used for this study. The research paradigm uses a combination of positivist and phenomenological approaches. An adapted case study methodology was selected to allow for both quantitative and qualitative data to be described. This chapter also highlights the data collection methods used, the use of both inductive and deductive reasoning, the nature of data used and the different data analysis techniques. The strengths and limitations of the methodology are also addressed in this chapter, especially the key issues of validity, reliability and generalisability.

Chapter Seven contains an analysis of the secondary and primary data for the three South Australian universities. The secondary data highlights the extent of Cooperative Research Centre (CRC) and Australian Research Council (ARC) linkage participation by the different university groupings and the nature of industry partners and research fields undertaken in these processes. The chapter analyses and describes the strength and structure of each university relating to industry-university collaborations. The chapter highlights the views of university academics from the three South Australian universities and the differing benefits and risks on collaborating with industry.

Chapter Eight analyses the information obtained from the advanced manufacturing case study. It discusses the data gathered though the cases study for the two different manufacturing regions. The chapter identifies and describes the business relationships within the different regions. The advantages and disadvantages from being located within these regions are discussed with an understanding if the levels of participation, business growth and links with the region are region dependent.

Chapter Nine presents the conclusions of the study and discusses the implications for industry-university links and location advantages for advanced manufacturing businesses. It draws conclusions on the difference between the universities in collaborating with industry and whether this is due to their different backgrounds. This chapter also discusses the conclusions drawn from the implications of advanced manufacturing companies being located in different regions and whether these advantages are region specific or industry specific. In discussing these conclusions, the contributions this study makes to furthering the area of industry-university links and clustering are summarised.

Chapter Two

Learning and Technology

2.1 Introduction

Various research efforts into industry performance, innovation, export levels and clustering have revealed that industry type plays a vital role, and this is particularly evident in the 'advanced manufacturing' industry. Co-operative links between the advanced manufacturing industry and universities are important as this industry type relies on tacit knowledge and knowledge transfer to remain competitive. In many countries the advanced manufacturing industry represents a key part of the general manufacturing industry, especially in the areas of high technology niche products. Universities are now taking a more active role in collaborating with industry, especially industry types that fit their expertise and knowledge base. Along with these links, universities are taking a leading role in developing and enhancing the regions they are located in.

This chapter highlights the roles that the higher education system and manufacturing industry play within the Australian economy. Section 2.2 describes what is meant by the 'higher education sector', and the role this sector plays within the Australian economy. The alignment of different universities into specific groupings is discussed, together with the role universities play in regional development. Section 2.3 discusses the context of the Australian manufacturing industry including its history and the influence it imparts on the Australian economy. In discussing the manufacturing sector, particular emphasis is placed on a specific definition of advanced manufacturing and the nature of the advanced manufacturing industry. Lastly this section discusses Small-Medium Enterprises (SMEs) in the manufacturing industry and their relative innovation levels.

2.2 Australian Higher Education Sector

The Australian higher education system is comprised of universities and other higher education providers and institutions. The sector plays a key role in the country's economy by providing a skilled and well educated workforce. In 2007 the Australian higher education system comprised of thirty seven public institutions and two private institutions, one Australian branch of an overseas university and four self-accredited higher education institutions (COA, 2008). The objects of the current legislative basis, the Higher Education Support Act 2003 (COA, 2008), are to:

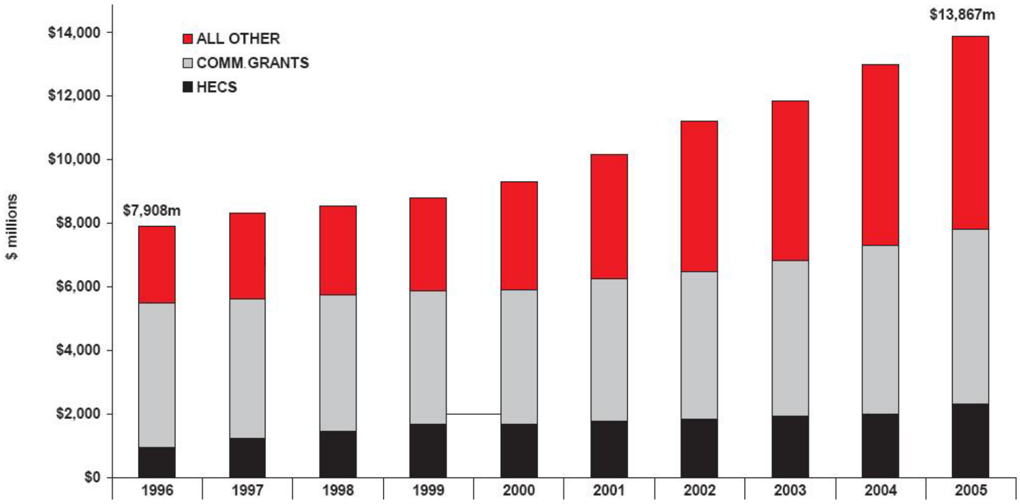
- support a higher education system
- support the distinctive purposes of universities
- strengthen Australia's knowledge base
- support students undertaking higher education

The Australian Government has the responsibility for funding higher education and achieves this largely through:

- the Commonwealth Grant Scheme which provides a specific number of supported places
- the Higher Education Loan Programme which provides financial assistance to students
- Commonwealth Scholarships
- a range of grants for specific purposes

The higher education sector is a major component of the Australian economy and in 2006' the sector had total revenue of $15.5 billion and employed 92,000 people (COA, 2008). The sector is also a major export earner and in 2007 the overall education export earnings were $12.5 billion, placing education behind only coal and iron ore exports (COA, 2008). The higher education sector is increasing and can now be considered as being an industry in its own right. Total university income has risen nearly 75% from 1996 to 2005 (Figure 2.1). In this time period, income from Commonwealth grants increased around 20% while income from all other sources and Higher Education Contribution Scheme (HECS), have both increased by over 100%.

Figure 2.1: Total university income from 1996 to 2005

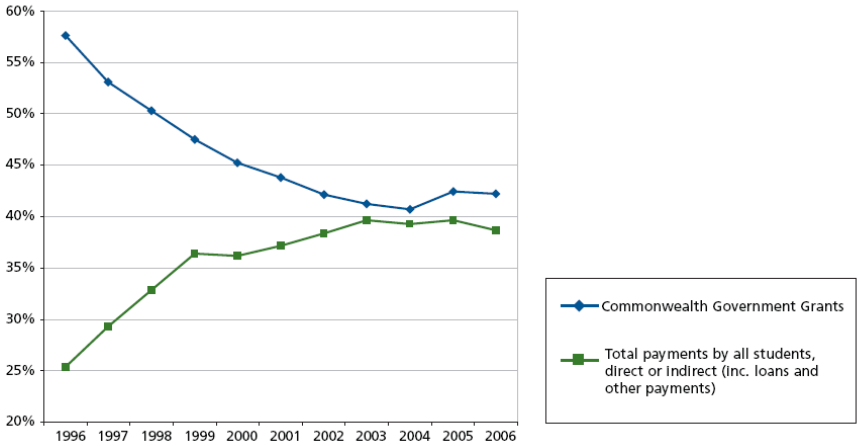


All other is consultancy, donations, investment incomes, royalties and net results of joint ventures

Source: DEST Selected Higher Education Statistics, 2006

The shift away from the reliance of universities on government grants for their income is best shown by Figure 2.1 and Figure 2.2, which reveals that university incomes are becoming increasingly contingent on competing for non-government funds.

Figure 2.2: Proportion of total university revenue from Commonwealth grants and from HECS and charges, 1996-2006



Source: DEST Selected Higher Education Statistics, 2006

Another impetus for increasing the revenues of higher education institutions is domestic and international student numbers. In the years 1997 to 2006 there was an increase of 7.8% in the number of domestic students, while for the same period the proportion of international students has risen rapidly from 9.6% to 25.5%. This actually represents a 300% increase in the number of international students during that time period. As international students pay larger tuition fees than domestic students, an increase in the number of international students significantly increases the revenues of higher education institutions. The numbers also tend to increase when the Australian dollar is weaker against other currencies, as more international students enrol in Australian universities to receive excellent teaching and degrees at a cost lower than that in their own countries.

2.2.1 University Groupings

In Australia there are four main groupings of universities. These groupings have been formed to capitalise on the similar strengths and objectives of the member universities. Being a member of these groupings allows the university to capture the advantages of increased lobbying power, marketing advantages and benefits from collaboration.

The four main active groups are:

- Innovative Research Universities Australia (IRU)
- Group of Eight (Go8)
- Australian Technology Network (ATN)
- New Generation Universities (NGU)

There are other Australian universities which are not aligned with these groupings, but this doesn’t exclude them from having their own particular strengths and research focus. The locations of the member universities for the Innovative Research Universities Australia, Group of Eight and Australian Technology Network are shown in Figure 2.3.

Figure 2.3: University locations for member universities of the IRU, Go8 and ATN

2.2.1.1 Innovative Research Universities Australia (IRU)

The IRU grouping was formed in 2003 and draws together six internationally recognised, student focused universities who share common goals and missions. The universities are located in capital cities and major regional cities. The universities have developed a distinction from other groupings by developing and embracing innovative approaches to teaching, research and community involvement.

2.2.1.2 Group of Eight (Go8)

The Go8 grouping represents eight of Australia's leading universities. They make this claim from statistics which highlight they are leaders in areas such as research outputs, industry links, graduate outcomes and the competency of their academic staff. The group started meeting informally in 1994 and was incorporated in 1999 and consists of the most prestigious and wealthy universities in the country. The grouping has a member university in each state capital city except Tasmania and Northern Territory. The group exists to enhance the value of its member universities and their contributions to the generation of knowledge, the development of skilled graduates, research collaborations with industry and to the nation's social and economic prosperity.

2.2.1.3 Australian Technology Network (ATN)

The ATN is a coalition of five Australian universities located within each capital city except Hobart. The common background of these universities comes from the fact that all five were formerly institutes of technology before becoming accredited universities. With this background in mind, the member universities share a common focus on the practical application of tertiary degrees and research. The member universities share a long history of working with industry and so have been able to develop a flexible structure that allows for excellence in delivering practical collaborative research results. This results in the production graduates and research that are closely aligned to the needs of industry and the wider society. The grouping is also the largest provider of international education with 25% of international students studying at an ATN university.

2.2.1.4 New Generation Universities

The NGU grouping comprises 10 universities and is limited to institutions that have received their accreditation since 1970. They have a distinctive approach to university operations in the interactions of learning, research teaching and business and government engagement.

The above university groupings reveal that Australia's universities have a broad variety of different goals, missions, and teaching and research structures. A full detailed list of groupings and member universities can be seen in Appendix B.

2.2.2 Backing Australia's Ability

With the view that ideas, knowledge and skills are becoming an essential basis for economic and social progress, the Federal Government identified science and innovation as a strategic policy priority and launched the $3 billion Backing Australia's Ability strategy in 2001. At the time this strategy was the largest ever investment in Australian innovation, and it built upon the substantial funding already invested by the Federal Government in research commercialisation and skills. This strategy has now been extended with a further $5.3 billion in under the Backing Australia's Ability – Building Our Future through Science and Innovation scheme which is aimed at the following three key elements of the innovation process:

- strengthening Australia's ability to undertake research and generate ideas
- increasing the commercialisation of these ideas and research
- developing and retaining these skills in Australia

Backing Australia's Ability, along with the National Research Priorities and associated priority goals, allows Australia's research effort to be aligned with the community's economic, social and environmental goals.

2.2.3 Regional Development

Growth of a region depends on the region's ability to attract and retain businesses. In turn, this ability depends on a set of physical, social and economic factors. Common factors, including agglomeration economies, trust, small firm networks and supportive education institutions (Keane & Allison, 1999), appear to underpin the success of a region.

Universities play a key role in the economic development of a region from both an economic and social viewpoint. Buys and Bursnall (2007) determined that effective partnerships between universities, businesses, governments and residents are an important part of community growth. The role of universities involves creating a knowledge supply for the specific knowledge market located within a region.

Doutriaux (2003) found that in high tech clusters, high tech development would not have occurred without a strong knowledge base. Universities contribute to this by producing skilled graduates, knowledge through academic research and contributing to the general education of the local population. Another important role played by universities in times of economic restructuring is as large institutions that generate significant financial income and support regional infrastructure (Garlick, 1998).

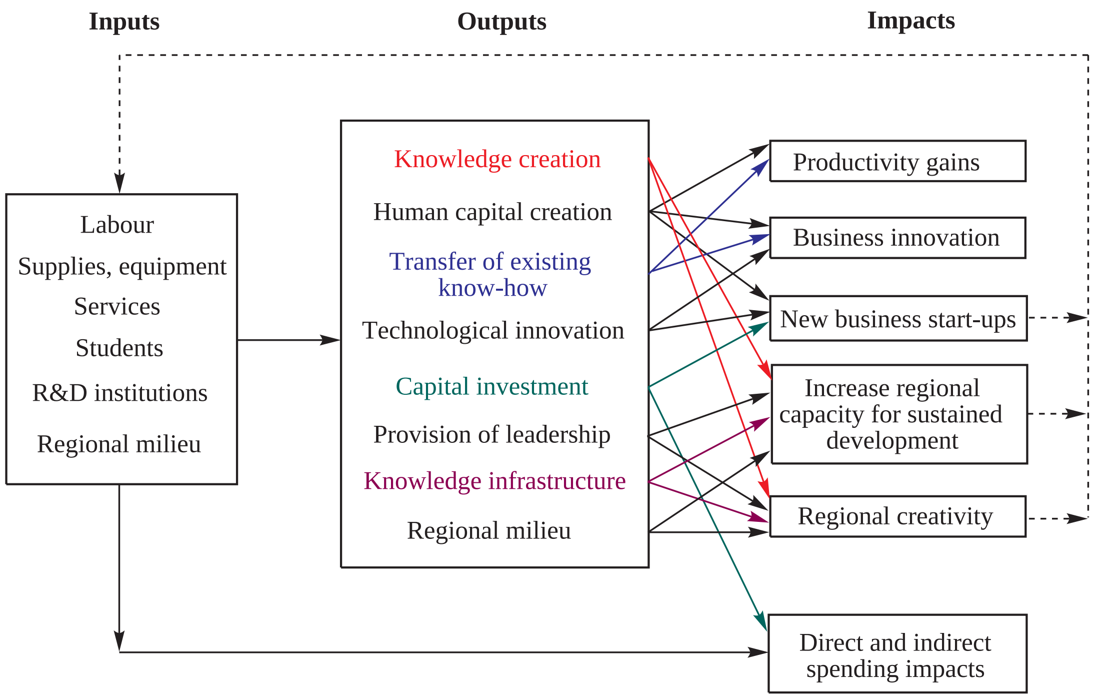
Goldstein *et al.* (1995) describes eight university outputs that potentially have an influence on regional economic development:

- knowledge creation
- human capital creation
- transfer of existing know-how
- technological innovation
- capital investment
- provision of regional leadership
- co-production of the knowledge infrastructure
- co-production of a particular type of regional milieu

These outputs are expected to have differing effects on a number of regional economic factors and the various outputs and regional economic impact relationships are shown in Figure 2.4.

Mansfield and Lee (1996) determined that companies prefer to have links with local university researchers. Kaufmann and Tödtling (2001) determined that for innovative companies, the providers and mediators of technology and knowledge such as consultants and universities are located within the same region as the company. This reveals that interactions between companies and universities often require close proximity to allow for frequent contact and easy knowledge transfer.

Figure 2.4: University outputs and impacts on economic development (Goldstein et al. 1995)



This has led many local governments using university research as a key component of their economic development strategies. Local governments have realised that university-industry collaborations play a central role in local economies by developing new high technology start-ups and by attracting new high-technology and R&D companies to the local regions. This increases employment, income and the level of knowledge within the region. The increased role of universities in both national and regional development requires the creation of new development agencies, with the focus of creating connections between business and universities across regions and nations.

Huggins *et al.* (2008) note that for universities to continue playing a regional economic development role, it is vital that knowledge transfer and networks are fully supported through university and government initiatives. Aside from knowledge development, universities are considerable employers within a region and usually spend a large amount on local goods and services. As there is increasing competition by universities to attract funding and students, universities now view the establishment of strong, long term linkages within their local region as being of critical value and strategic importance (University of Western Sydney, 1997)

2.3 Manufacturing

In its simplest form, manufacturing is defined as the making of goods or products by manual or mechanical labour, especially on a large scale. Under the ANZSIC the manufacturing division includes units that predominantly engage in physical or chemical transformation of materials, substances or components into new products. This covers a wide range of different goods ranging from ships and vehicles to electronics and pharmaceuticals.

In 2006, the manufacturing sector in Australia contributed to 11% of Australia's GDP, which equates to nearly $88.3 billion. Exports from this sector were valued at $67.4 billion and the sector employed nearly 1.1 million people. Its contribution to GDP and employment has been declining over the last five years but it still remains an essential and vital component of the Australian economy. This decline is forcing manufacturing businesses to move into the production of more high-technology products or what is termed, elaborately transformed products (ETP). This term refers to the amount of processing that is performed on the inputs to produce a final product. Simply transformed products (STP) are basic products such as unworked iron, steel and non-ferrous products. ETPs constitute a major portion of finished products that have unique qualities and are highly value added.

2.3.1 Advanced Manufacturing Industry

The advanced manufacturing industry is a key and critical part of the overall manufacturing industry. It is defined by the OECD as computer controlled or micro-electronics based equipment used in the manufacture or handling of a product. This industry is difficult to specify as a distinct industry as it is spread across several different segments. This industry is predominantly, but not exclusively, located within the following industry segments:

- machine tool manufacture
- cutting tool manufacture
- die/mould manufacturing
- precision engineering
- robotics and other automated equipment for manufacture
- general engineering
- design for manufacture

In Australia, the advanced manufacturing industry lies within the broader industry segment of Industrial Machinery and Equipment. This segment is the second largest in Australia, with an annual income of $12 billion. The competitive advantage for Australia's advanced manufacturing industry is based on knowledge, skills and the development of technologies and niche products, as opposed to low wages or other financial considerations.

Businesses that are involved in the advanced manufacturing sector are usually classed as being high-technology and are mainly SMEs. The next section entails a definition of SMEs, the importance of high-technology SMEs and the reason these enterprises need to undertake linkages.

2.3.2 SMEs

Small to medium enterprises are businesses whose employee numbers or turnover is below certain defined limits. There is no universal or standard definition of a SME, however SMEs are becoming increasingly important in economic and innovative activities. Several studies (Birch, 1981; Keeble & Wever, 1986; Acs and Audretsch, 1993) have shown that since the 1970s, economic activity due to small firms (as opposed to large) has increased significantly in European and North American countries. Birch (1981) reported that small firms are now the engine of USA economic growth and most new jobs generated were due to these firms. Table 2.1 shows the different definitions of SMEs and the role SMEs play in employment.

Table 2.1: Different SME definitions and importance

Australia	**ABS Definition** No. of Staff	**Micro** 1-4	**Small** 5-19	**Medium** 20-199	**SME** 1-199	**Large** >199
	OECD Definition No. of Staff	**Micro** 1-9	**Small** 10-49	**Medium** 50-499	**SME** 1-499	**Large** >499
	Number of Enterprises (%)				99	1
	Employment (%)	25	47	8	70	30
	Share of Production (%)	11.3	22.3	11	44.6	55.4
China	Employment (%)				**SME** 75	**Large** 25
European Union	No. of Staff	**Micro** 1-9	**Small** 10-49	**Medium** 50-249	**SME** 1-249	**Large** >249
	Number of Enterprises (%)	93	5.9	0.9	99.8	0.2
	Employment (%)	33	19	14	66	34
Japan	No. of Staff				**SME** 1-299	**Large** >299
	Number of Enterprises (%)				99.7	0.3
	Employment (%)				70	30
United States of America	No. of Staff	**Very Small** 1-19	**Small** 20-99	**Medium** 100-499	**SME** 1-499	**Large** >499
	Number of Enterprises (%)	77	9	12	98	2
	Employment (%)	18	15	27	60	40

This table is suggestive only due to different collection methods and sources of data.

Table 2.1 reveals that in most countries, SMEs constitute over 98% of total enterprises and 60% or more of total employment.

Keeble (1990) noted that the skewed distribution of firm size is due to three main overlapping economic processes which are:

- pressures towards small business creation such as enforced unemployment and entrepreneurship

- large firm externalisation which leads to subcontracting by small manufacturing and service businesses
- increased differentiation of products and processes and diversification of market demand which provides opportunities for small businesses in specific niche markets

Since the 1970s, SMEs have challenged large firms operating in similar market places and are now leaders in the generation of innovative products and processes. Their advantage over large firms is due to the flexibility allowed by their organisational and institutional arrangements (Longhi & Keeble, 2002). This flexibility is now a key attribute, as economies of scale and mass production are no longer essential for business success.

2.3.3 High Technology SMEs

Businesses involved in advanced manufacturing can be considered as high-technology businesses due to reliance on scientific and technological knowledge. The term ‘high technology’ is used loosely in a variety of contexts, but it generally refers to businesses whose products or services encompass new, advanced and innovative technologies that are developed via the application of tacit knowledge and expertise (Keeble and Wilkinson, 1999). Keeble and Wilkinson note that these firms regard such tacit knowledge and expertise as the firm’s key competitive advantage and usually have a high R&D intensity.

Even though high-technology SMEs account for only a small fraction of SMEs, research has shown that they have a more positive and longer lasting effect on regional and national economies (Keeble and Wilkinson, 2002). The two major sources of high-technology small firm entrepreneurs are established firms and higher education institutions and so new firms are more likely to concentrate around existing firms, universities and research institutions (Oakey, 1995). SMEs are significantly more innovative, grow more rapidly in both employment and sales and are more likely to survive over a long period (Storey and Tether, 1998).

Hughes (1998) determined that high-technology manufacturing SMEs differ in four ways from low-technology or conventional manufacturing SMEs:

- innovation – high–technology firms have higher levels of product innovations and plan further product innovations
- links – high-technology firms are more likely to engage in collaborations with other firms and universities via formal and informal partnerships
- markets – high-technology firms are more targeted
- advice – high-technology firms seek greater external business advice on business strategy, marketing, product and service design, staff recruitment and training

The growth and performance of high-technology SMEs are dependent to different degrees on inter-SME networks and links with universities, large firms and public research institutes. Proximity is important for the effectiveness of inter-firm networks. These networks and links allow SMEs to increase their innovation resources, which is becoming the key to the survival and success of small firms (Heunks, 1998). Links involve different 'institutions' which have an impact on the performance of high-technology SMEs, and are divided into eight key parts (Edquist, 1997):

- universities – skilled graduates, knowledge transfer, R&D spin-offs
- non-university research institutions – knowledge transfer, spin-offs
- science parks – agglomeration economies, infrastructure
- technology transfer institutions – consulting and support services
- entrepreneurs – political and financial support
- large firms – spin-outs, sub-contracting, financing of innovation and projects
- technology fairs – networking opportunities
- technology policy – innovation and R&D grants

Firm characteristics such as size, innovation strategy, organisational structure and business direction act as institutional impacts filters (Edquist, 1997). Different 'institutions' will have varying effects on regions which is in turn dependent on the unique characteristics of each region.

This is seen in Table 2.2, which shows that ‘institutions’ have different levels of impact on high-technology SMEs for different European regions.

Table 2.2: Institution impact on high-technology SMEs in 10 European regions (Tamásy and Sternberg, 2002)

Regions	Institutions						
	Higher Education	Research	Science Parks, Innovation Centres	Technology Transfer	Key Entrepren-eurs or Persons	Large Firms	Technology Fairs
Barcelona	◧	◧	◧	□	□	◧	◧
Cambridge	■	◧	■	□	◧	□	□
Göteborg	◧	◧	◧	◧	□	◧	◧
Grenoble	◧	■	■	◧	◧	◧	□
Helsinki	■	■	■	◧	□	■	□
Milan	◧	■	◧	□	■	□	■
Munich	◧	◧	□	□	■	■	◧
Oxford	■	◧	◧	◧	■	◧	□
Utrecht/ Randstad	◧	◧	◧	□	□	◧	◧
Sophia-Antipolis	◧	■	■	□	■	◧	□

This assessment is based upon the relative significance of the institutions in each region

■ strong impact on high-technology SMEs

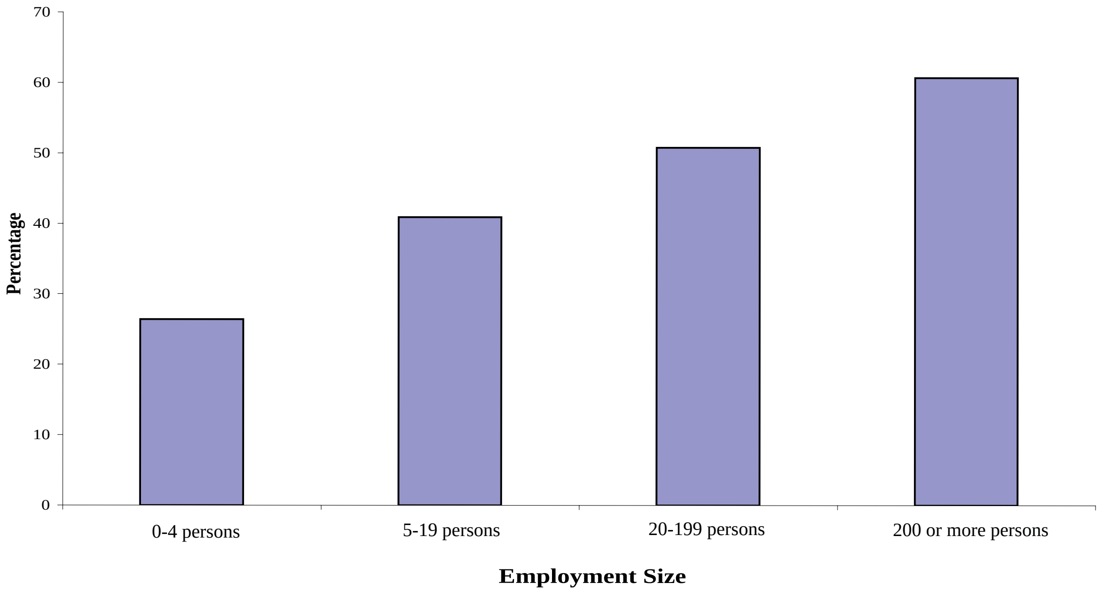
◧ medium impact on high-technology SMEs

□ almost no impact on high-technology SMEs

Globalisation and rapid technology changes are the driving forces behind large firms and technology intensive firms basing their competitive strategies and advantage on innovation (Longhi and Keeble, 2002). Firm size has a significant effect on the rate of innovation. Large companies are able to perform in house R&D as they are able to spend considerably more money on R&D then smaller companies. These smaller companies usually undertake R&D by sharing the costs with a research partner who maybe a competing company, university or another institution that performs R&D.

This is highlighted in Figure 2.5 which reveals that over 60% of companies employing over 200 employees introduced or implemented innovation in 2006, compared to only 41% of companies employing 5-19 people and 26% employing 0-4 people (ABS, 2008).

Figure 2.5: Percentage of Businesses introducing or implementing innovation by employment size, 2006-07



Arrow (1983) notes that a greater number of original and less costly innovations will originate from small firms, while innovations involving higher development costs will come from larger firms. This is due to small firms being able to offset the lack of materials and resources that larger firms have, through their flexibility, innovation strategies and behavioural advantages (Nooteboom, 1994).

Spillovers from universities are more important for the innovative activities of SMEs whereas large firms are more concerned with industrial R&D spillovers (Acs *et al.* 1994). The effectiveness of these spillovers decreases over distance and so is considered to be localised.

2.4 Chapter Summary

This chapter has provided an overview on the nature of the higher education and advanced manufacturing sectors. From this overview, characteristics that are unique to both sectors are introduced. An understanding of both sectors allows this study to be positioned to investigate university-industry links and business links in advanced manufacturing regions.

The higher education sector plays a vital and essential role in Australia's economy by educating skilled graduates and conducting applied and fundamental research. Universities in Australia are aligned into four main groupings based on their similar objectives and strengths. They are playing a major role in regional development through employment and spending in a region, generating information and knowledge, collaborations with regional industry and community associations, and by contributing to the development of the region as a learning region in the knowledge economy.

The manufacturing sector is a vital component of the Australian economy and contributes to a large proportion of the GDP and employment, but this contribution is declining. This decline is forcing manufacturers to move into niche markets were they have a technological advantage. The advanced manufacturing industry is growing in Australia due to its competitive advantage, which is based on knowledge and skills.

Economies around the world are dominated by small to medium enterprises, which are vital for economic growth. There is no standard definition of SMEs which means that it is difficult to compare research on them from different countries. High-technology SMEs only constitute a small fraction of SMEs but they exert a more positive effect on the economy. They are more likely to engage in collaborative agreements with other businesses and research institutions. They exert a range of cascading effects as they employ higher numbers of high-skilled and high-income professional scientific and managerial staff.

Chapter Three

University-Industry Links

3.1 Introduction

Knowledge is now viewed as crucial for the competitiveness of both a region and a business. It plays a vital part in the innovation process, national economic growth and regional economic development. This has led many economists to label the present economy as a knowledge economy. Understanding the role knowledge plays in the economy, has led many countries to develop programs and policies to increase the levels of university-industry collaborations. Universities are now undertaking multiple roles in educating students, performing research, linking with industry to drive innovation and enhancing regional development. These links, which are gaining more attention, are now viewed as being important for the growth of regions, industry and universities. This chapter encompasses the literature on the role of knowledge, and university-industry links and also provides the framework for the understanding of these key concepts of knowledge, R&D and industry–university collaborations.

This chapter explores university-industry links and the roles that university, industry and government play in a knowledge based economy. The chapter begins by defining a knowledge based economy and the different types of knowledge. It then describes the use of knowledge in a national innovation system, R&D with a focus on the levels of R&D in Australia. There is particular focus on the concept of university-industry links and the advantages and disadvantages of those links for both participants. The obstacles to developing these links and government incentives to nurture and increase industry-university collaboration are introduced.

3.2 Knowledge Based Economy

Countries economies are increasingly being based not on primary resources but on knowledge and information. Knowledge is now viewed as a driver of prosperity, productivity and economic growth. The term applied to this economic driver is ‘knowledge based economy’ which refers to the recognition of the place that knowledge and technology take in growing an economy. This increase in prosperity is in accordance with one of the major goals of government which is to raise living standards and improve the quality of life. This is shown in Figure 3.1 which is a simplified linear model of the role knowledge plays in increasing prosperity.

Figure 3.1: Simple linear model of knowledge as a driver of prosperity

Knowledge → R&D → Innovation → Increased Productivity and Competitiveness → Increased Prosperity

Adapted from Link (2006)

Drucker (1969) introduced this concept of a knowledge based economy when he described the difference between a knowledge worker as opposed to a manual worker. Economists are now researching new theories and models for this knowledge based economy and their attempts reflect the role knowledge and technology undertake in increasing productivity and driving economic growth. Understanding the role knowledge plays in the economy highlights the need to keep investing in research and development, education, training and industry-university links.

3.2.1 Tacit and Codified Knowledge

Knowledge, education (known as ‘human capital’) and technology, has always taken a central role in economic growth and knowledge can now be viewed as a business product and asset. Knowledge can be divided into two key sectors being ‘tacit knowledge’ and ‘codified knowledge.’ Tacit knowledge can be defined as the knowledge carried by humans in their minds and not in an accessible form, so it is not easily transferable (Polayni, 1966).

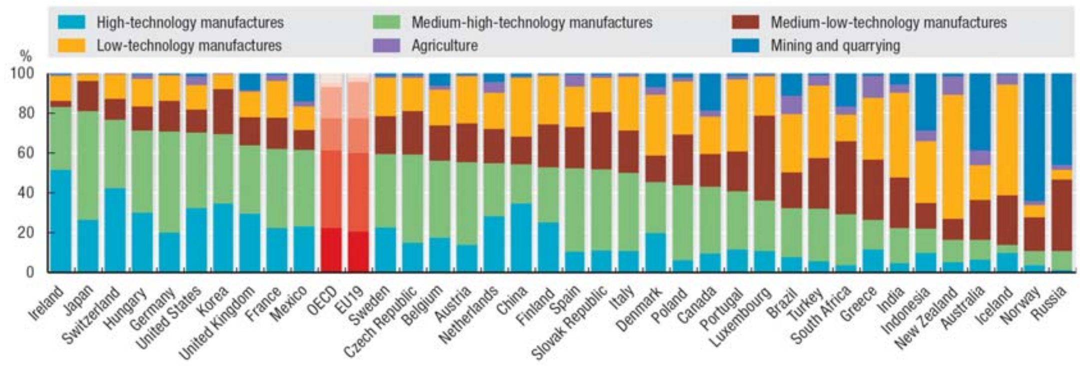
Tacit knowledge is often referred to as 'know how' which involves skills and learning, that can only be gained through training or personal experiences. The effective transfer of tacit knowledge requires extensive trust and personal contact. Tacit knowledge is unique to each company and so is highly valuable for business growth as it is critical in the innovation process. Takeuchi (1995) implied that Japanese businesses have been successful in collecting the individual tacit knowledge within the business which has allowed these businesses to be more innovative.

Codified knowledge is information that is easily transferable through information technologies and organisations over long distances; and is generally referred to as the 'know what' and the 'know why' which incorporates the knowledge about facts and scientific knowledge of the principles and laws of nature. The concept of learning is related to both of these aspects of knowledge. The development of these two types of knowledge highlights the importance of continuous learning by individuals and companies. The knowledge economy is characterised by the drive of converting tacit knowledge into codified knowledge. As well as knowledge investments, knowledge distribution is also essential for economic growth. This distribution can be achieved through formal and informal networks. These networks have been referred to as the 'know who' and are the relationships which allow for the access, diffusion and use of knowledge efficiently.

Educated and skilled workers are becoming more valuable in this economy, as they are a means for companies to obtain a high level of both tacit and codified knowledge. This demand for highly-skilled workers is a characteristic of the knowledge economy. These high skilled workers are usually paid more than lower skilled workers and obtain employment more easily in high-technology companies. An OECD (1996) report noted that the high-technology manufacturing share of OECD manufacturing exports had more than doubled, to reach 20-25%, for the decade 1983-1993.

For this decade Australia’s level had increased from 2.8% to 10.3%. This level has remained relatively the same as seen in Figure 3.2 from the OECD (2007) which highlights that Australia is at the bottom end of high-technology exports due to its reliance on primary resources such as mining and agriculture. The 1996 report also estimated that more than 50% of Gross Domestic Product (GDP) in major OECD economies was now knowledge-based.

Figure 3.2: Share of technology industries in total exports of manufactured goods and primary products, 2005 (OECD, 2007)



Wood (2003) contests Australia is under performing in the knowledge based economy when measured against knowledge-based indicators. This economic measure is investment in knowledge and is defined as the sum of expenditures in R&D, on total higher education and on software. Figure 3.3 highlights Woods (2003) statement and reveals that Australia (3.8%) is below the OECD average (4.4%) in relation to investment in knowledge development as percentage of GDP. Sweden which is ranked first spends 35% more of its GDP on knowledge development than Australia (Wood, 2003). The figure shows that in 1998, Australia spends above the OECD average on higher education knowledge development.

Figure 3.3: Investment in knowledge as a percentage of GDP, 1998 (OECD, 2001)

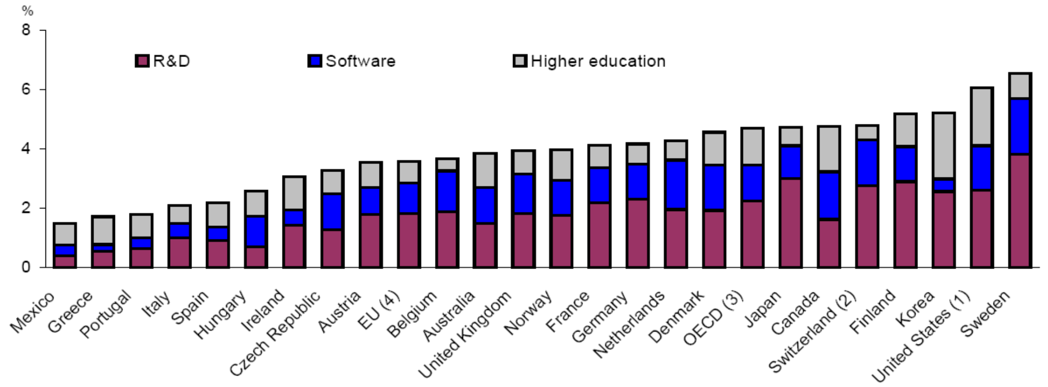
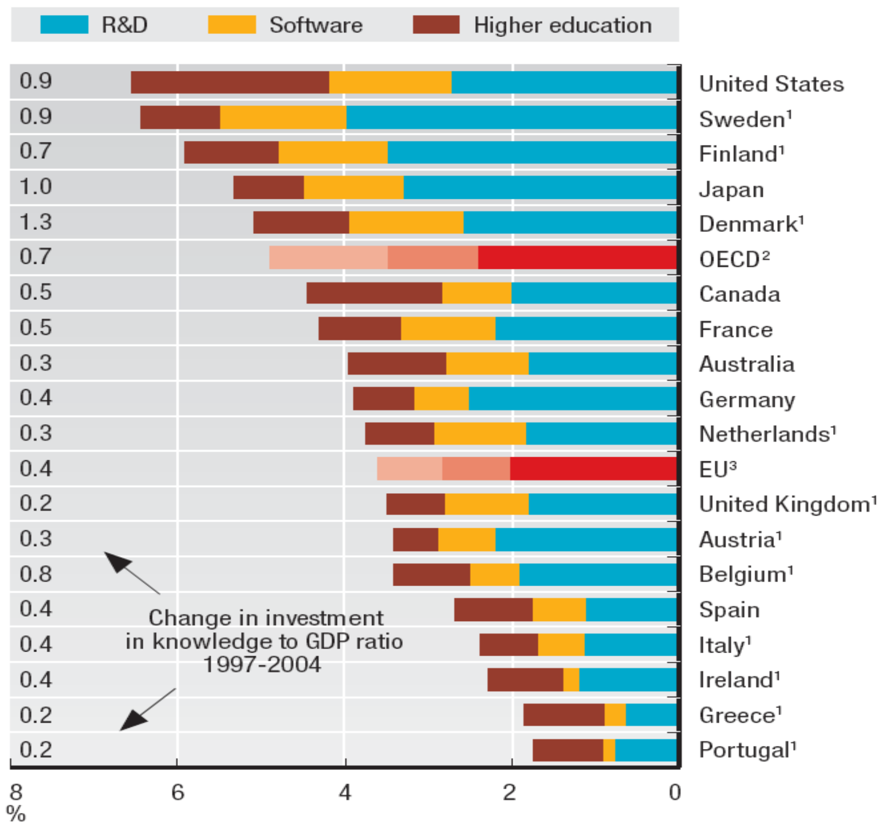


Figure 3.4 shows that Australia's investment in knowledge as a percentage of GDP in 2004 had increased slightly to 4%, but is still below the OECD average of 4.8% and still considerably less than 6.6%, the United States of America (USA) invests.

Figure 3.4: Investment in knowledge as a percentage of GDP, 2004 (OECD, 2007)



These figures reveal that State and Federal Governments in Australia need to develop and implement new policies for it to be competitive in the global knowledge-based economy. The driving force for Australia to be successful in this knowledge based economy will be dependent on its ability to generate new knowledge, ideas and technologies through research. Research has always been regarded as one of the main drivers of a countries competitiveness and economic growth in the ever increasing and changing global markets. The generation of new knowledge and commercial products in the area of high-technology manufacturing can be considered in terms of a national innovation system.

3.2.2 National Innovation Systems

A National Innovation System (NIS) acknowledges that the key to the innovative process is the flow of technology, knowledge and ideas among people, businesses and institutions on a national level. There is no single definition of a NIS, but some essential definitions (OECD, 1997) are:

- "… the network of institutions in the public and private sectors whose activities and interactions initiate, modify and diffuse new technologies." (Freeman, 1987).
- "… the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge … and are either located within or rooted inside the borders of a nation state." (Lundvall, 1992).
- "… a set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies." (Metcalfe, 1995)

According to the OECD (1997), the national innovation system approach has taken on increased importance in technology fields due to three factors:

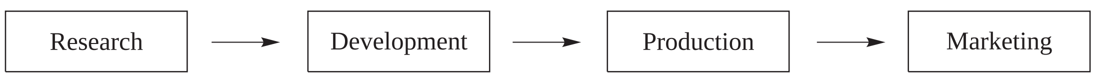
- the recognition of the economic importance of knowledge
- the increasing use of systems approaches
- the growing number of institutions involved in knowledge generation

There has been an increase in mapping knowledge flows as a complement to measuring knowledge investments. The intent of this mapping is to evaluate and compare the main channels for knowledge flows at a national level and to implement policies and approaches to improve these flows (OECD, 1997). The NIS also highlights the rise of the system approach to innovation as compared to the previous linear model of innovation.

3.2.2.1 Old and New Models of Innovation

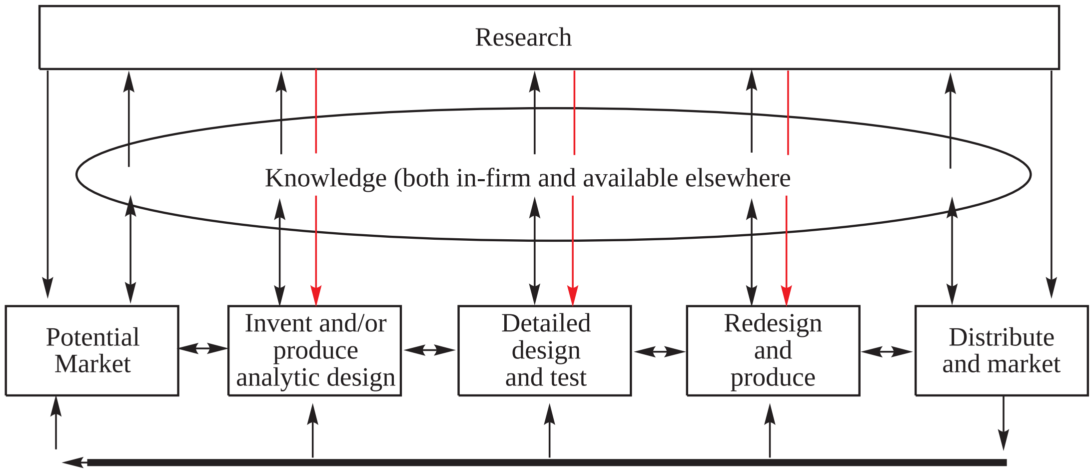
Innovation in the linear model is considered to be a process which proceeds via a fixed linear chain of different phases (Stein & Rosenberg, 1986). In this model, innovation begins with new scientific research and progresses through product development, production and concludes with the sale of new commercial products, services and processes as seen in Figure 3.5.

Figure 3.5: Linear Model of Innovation (Klein & Rosenberg, 1986)



It is now recognised that in reality, ideas and knowledge for innovation can originate from many sources and at any stage of research, development, marketing and sales. Innovation includes new products and processes, adaptation of original products and incremental improvements on existing processes. Klein and Rosenberg (1986) developed the chain-link model of innovation which details the results of interactions between various regional, national and international actors such as companies, universities, laboratories and consumers as seen in Figure 3.6 where the arrows indicate direction for the flow of knowledge.

Figure 3.6: Chain-link model of innovation (Klein & Rosenberg, 1986)



An innovative firm is one which operates within a complex network of co-operating and competing businesses, and other government and education institutions. These interactions create and enhance joint ventures and close links to develop and improve products and processes. This is evident in the knowledge-based economy where companies search for these links to help them spread the costs and risks associated with innovation, share assets in manufacturing, marketing and distribution, gain rights to intellectual property and gain access to new technology and knowledge (OECD, 1996).

3.2.2.2 Innovation, Science and Knowledge Flow

In a knowledge based economy, an increasing number of institutions are specialising in the production and diffusion of knowledge, while other institutions are researching and mapping increasing innovation, knowledge flows and national innovation systems through the use of national innovation surveys. Each country will have its own unique national innovation system profile depending on the organisation and level of the higher education sector, extent and orientation of government-funded research and the level of industry R&D.

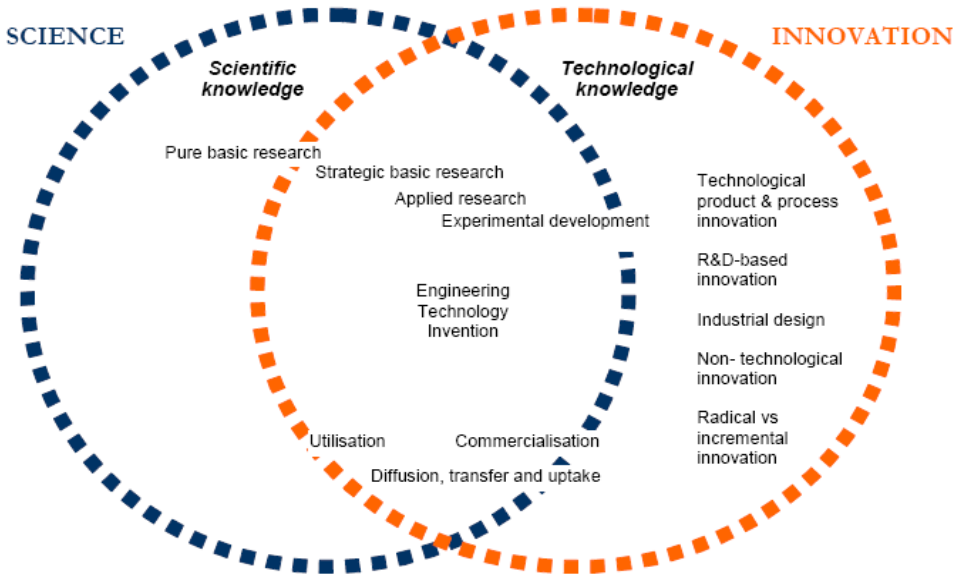
There are four basic channels through which knowledge can flow and a variety of approaches to measure these flows in a national innovation system (OECD, 1997) are:

- interactions among companies
- interactions among companies, universities and public research laboratories
- diffusion of knowledge and technology to companies
- movement of personnel

Innovation could be considered as a flow of scientific and technical knowledge between institutions. Innovation and science are linked together in many complex relationships and the mapping Australian science and innovation report (COA, 2003) highlights the relationships concerning science and innovation (Figure 3.7). These relationships are simple, in that they don't represent the complex feedback loops and interactions that exist.

R&D is the critical factor that supports and maintains both science and innovation. The importance of this has been highlighted by the Federal government's Backing Australia's Ability package, which provided an additional $3 billion in research funding.

Figure 3.7: Conceptual Map – Scope of science and innovation (COA, 2003)



3.3 Research and Development

R&D is defined by the OCED (2007) as “creative work undertaken on a systematic basis, in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications”. It is critical for the economic growth of countries and businesses and performs a crucial role within science and innovation. Industries, private research institutions and public universities will undertake different forms of R&D and these levels will differ depending on the R&D required.

There are four types of research that are used for the purposes of statistical data collection (COA, 2003) are:

- pure basic research – experimental and theoretical work pursed for the progression of knowledge itself.
- strategic basic research – pursed in the expectation of useful outcomes or discoveries.
- applied research – original work performed to gain new knowledge with a desired application in view.
- experimental development – the creation of a new or improved product or process, using existing knowledge gained from research or practical experience.

All these categories overlap both, science and innovation, (see Figure 6) but basic research falls mainly in science/university while experimental development lies mainly within innovation/business (COA, 2003). Innovation is underpinned by the levels of R&D undertaken by businesses and research institutions.

3.3.1 R&D Nature and Relevance

R&D has a special economic significance in today’s economy as it is not only associated with new scientific and technological advancements, but R&D investment usually reflects a government’s or business’s commitment to sacrifice profit to improve its levels of R&D for the purpose of increasing future returns and profits. R&D activities are usually conducted in specialised centres that belong to businesses, universities and government organisations. Specific statistics, such as expenditure on R&D, number of patents, rates of peer-reviewed publications and innovation levels allows for a determination of the state of an industry, R&D effectiveness, and degree of competition and co-operation.

3.3.1.1 Industry Research and Development

Embedded in industry and business is the concept of entrepreneurship. The output of entrepreneurship is the development and promotion of one's original innovation or the adoption of another's innovation (Link, 2006). This would define an entrepreneur as one who perceives an opportunity and has the ability to act on this within the market (Hérbert & Link, 1989). One critical resource requirement for innovation is R&D, as it provides a base of knowledge for a business to undertake research into new scientific areas and the ability to act of these areas.

Businesses now view R&D and innovation as critical for the survival and growth of their business. They need to invest money into R&D to enable them to remain ahead of their competitors by finding new products and markets. They also see the need to acquire new knowledge and technology as a way of being competitive in a global economy. Link (2006) proposed that R&D serves two general purposes for active companies R&D:

- it provides the knowledge base that allows the company to respond to an opportunity with perceived strategic merit or technical opportunity
- provides an internal resource of R&D scientists that assists the company when making technical decisions on other's innovations and how they will interface with existing technologies at the company.

Businesses that do not conduct R&D can still be entrepreneurial through their innovations being introduced instead of produced. This involves hiring creative individuals and providing them with a work environment that allows them to fulfil their talents.

There are a number of factors that explain why a business doesn't innovate and under invests in R&D (Table 3.1).

Table 3.1: Factors creating barriers to innovation

Factor	Characteristics
High Technical Risk	Expected returns are less than the invetsment cost Cost of conducting research is excessive relative to the overall R&D budget
Time Intervals	Many R&D projects are characterised by the time required for the product to get to market Underinvestment in R&D increases as the time to market increases
Nature of Markets	Requires investments in combinations of technologies that reside in different industries Inability to accese these different technologies if they existed
Nature of Technology	Intellectual property rights cannot be assigned to the underlying R&D Competition in a particular technology area means reduced returns to cover R&D costs Resulting technology must be compatible and interoperable with other technologies
Industry Structure	A broad market reduces incentives due to technological lock-in and path dependency Complexity of a technology makes an agreement between buyer and seller to be costly

Adapted from Link (2006)

These factors are interrelated and overlap and any one factor is sufficient to cause a business to under invest in R&D, which prevents increasing levels of innovation and business growth. R&D collaborations formed between two or more businesses or universities, allows a business to overcome many of these innovation barriers. Industry innovation is increasingly becoming a combination of R&D performed internally and also with external partners (Adams, 2005).

A critical factor to the extent at which a company can undertake innovation and R&D not listed in Table 3.1 is the size of the company. In 2005-06, Australian companies employing more than 200 accounted for 66.8% of Business Expenditure on R&D (BERD), while companies employing between 20 and 199 constituted 20.1% of BERD. In 2001-02, 21% of BERD was performed in companies with less than 50 employees, while for the USA these companies only represent 5% of BERD (COA, 2003).

3.3.1.2 University Research and Development

Most industrialised countries governments invest considerable funds in to universities and higher education institutions. The primary roles of these higher education facilities, is to perform basic research and to produce well educated and trained students (Schmoch, 1997, Turpin *et al.* 1996). An expanding role of universities is to perform applied research that is closely aligned with industry and social requirements.

Research that is performed in universities and government research institutions has been shown to be a source of industrial innovation (Mansfield, 1998) and a force in driving high technology and economic growth (Narin *et al.* 1997). Rosenberg and Nelson (1994) note that engagement of industry for research collaboration will vary and depend on the university, faculty or academic involved. These research and collaboration roles indicate that universities are major and critical participants in the national innovation system of a country (Mowery & Sampat, 2005). They play an essential role by providing vital research infrastructure for basic and applied research for industry, where innovative activities can be performed (Lundvall, 1992; Nelson, 1993).

As well as a role in national innovation systems, universities play a key role in the economic development of a region. Buys and Bursnall (2007) determined that effective partnerships between universities, businesses, governments and residents are an important part of community growth. A university's role in regional development involves creating a knowledge supply for the specific knowledge market within the region. Doutriaux (2003) found that in high tech clusters, high-tech development would not have occurred without a strong knowledge base. Universities contribute to this base by being providers of skilled graduates, producers of knowledge through academic research and contributors to the general education of the local population. Mansfield and Lee (1996) determined that companies prefer to have links with local university researchers, usually within 100 miles of their company. Kaufmann and Tödtling (2001) determined for innovative companies that the providers and mediators of technology and knowledge such as consultants and universities are located within the same region as the company. This reveals that interactions between companies and universities often require close proximity to allow for frequent contacts and easy knowledge transfer.

Many local governments now use university research as a key component of their economic development strategies. Local governments have realised that university-industry collaborations play a central role in local economies by developing new high technology start-ups and by attracting new high-technology and R&D companies to the region. This increases employment and income and the level of knowledge within the region. This increased role of universities in national and regional development requires the creation of new development agencies, which will create and develop connections between businesses and universities across regions and nations.

Huggins *et al.* (2008) notes that for universities to continue this regional economic development role, it is vital that initiatives are developed to support knowledge transfer and networks. Aside from knowledge development, universities are considerable employers within the region and spend a large amount on local goods and services.

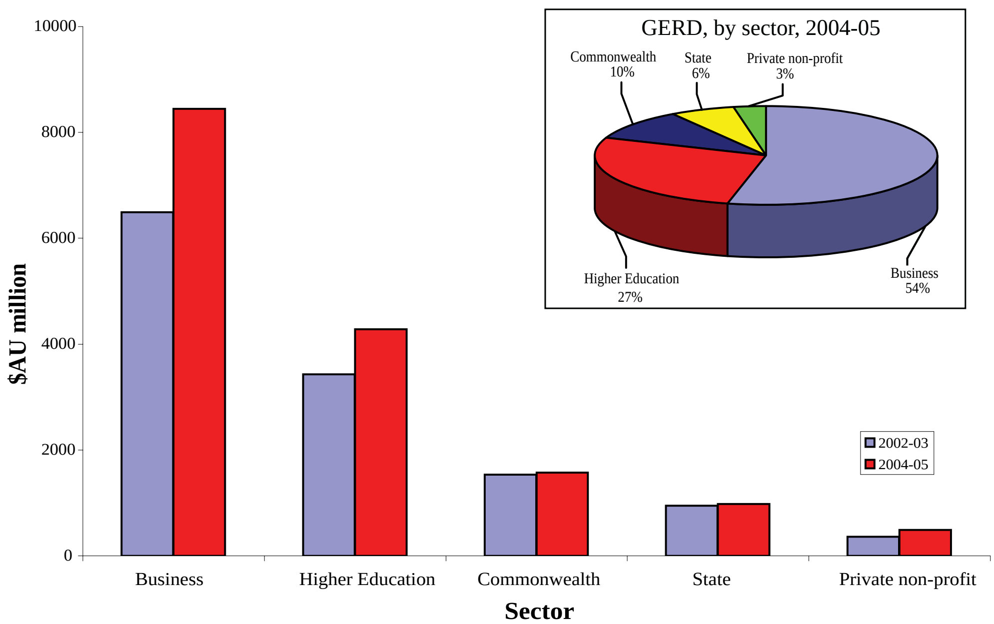
University research in certain faculties has been determined to be industry relevant and contributions from this research are impacting on economies. Mansfield (1991) found that for the years 1975-1985 over 10% of products or processes introduced by industry would have been impossible without academic research. The contribution of university research to the economy in the USA was further highlighted by The Association of University Technology Managers (AUTM) as cited in Morgan and

Strickland (2001) who found that for the financial year of 1998, USA university research introduced at least 385 new products and formed over 364 new companies at an estimated US$33.5 million in economic activity. For the same year university-generated licences created nearly 280,000 new jobs. These results were confirmed by Mansfield (1998) for the time period of 1986-1994 when he discovered that for the latter time period, the time lag between academic research and commercialisation of research findings had decreased when compared to 1975-1985.

3.3.2 The Australian Research and Development Scene

In 2004-05, Gross Expenditure on R&D (GERD) was $15,772.9 million in Australia. This represents an increase of 19.4% over 2002-03 (ABS, 2006a). Figure 3.8 shows there has been an increase in GERD for all sectors from 2002-03 to 2004-05, and insert shows that the largest proportion of the 2005 GERD was for the business sector followed by the higher education sector.

Figure 3.8: GERD by sector for 2002-03 and 2004-05, with percentage GERD by sector, 2004-05



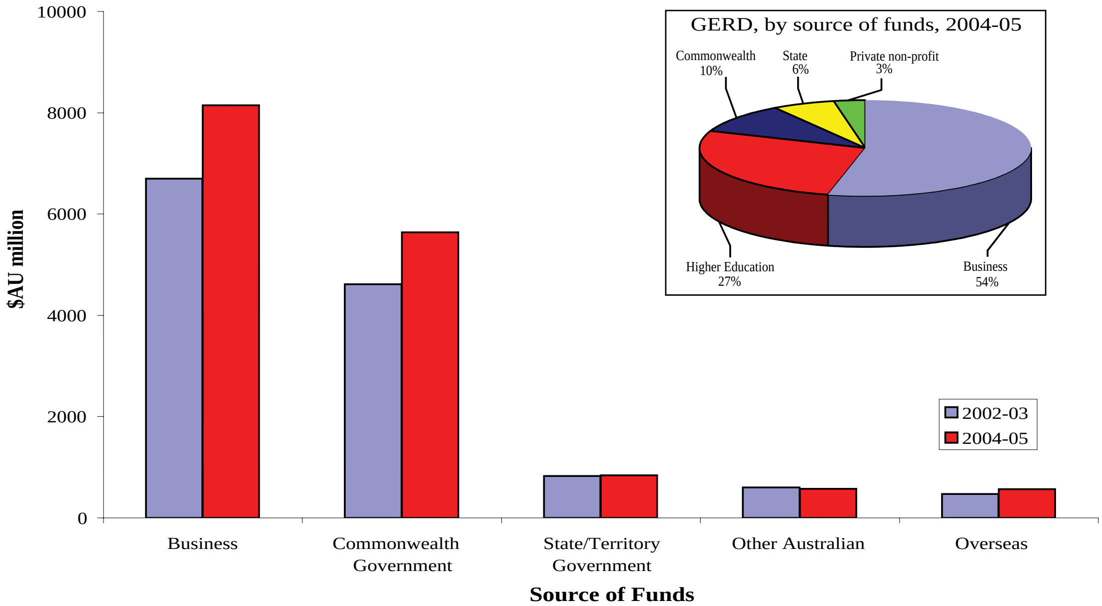
Source: ABS, Research and Experimental Development All Sector Summary, 2004-05.

In 2004-05, GERD represented 1.76% of the GDP, which is higher than the 1.69% in 2002-03, but his is well below the OCED average of 2.26%. Overall, GERD has been increasing at an average of 9.9% per year since 1996-97 (ABS, 2006a).

Figure 3.9 reveals that the major sources of R&D funding in Australia, is business and the Commonwealth government. There has been in an increase in funds of 21.6% and 22.2% respectively since 2002-03. The other sources of funds stayed relatively the same from 2002-03, but total funds increased by 19% when compared to 2002-03. The major sources of funds in 2005 were still business followed by the Commonwealth government.

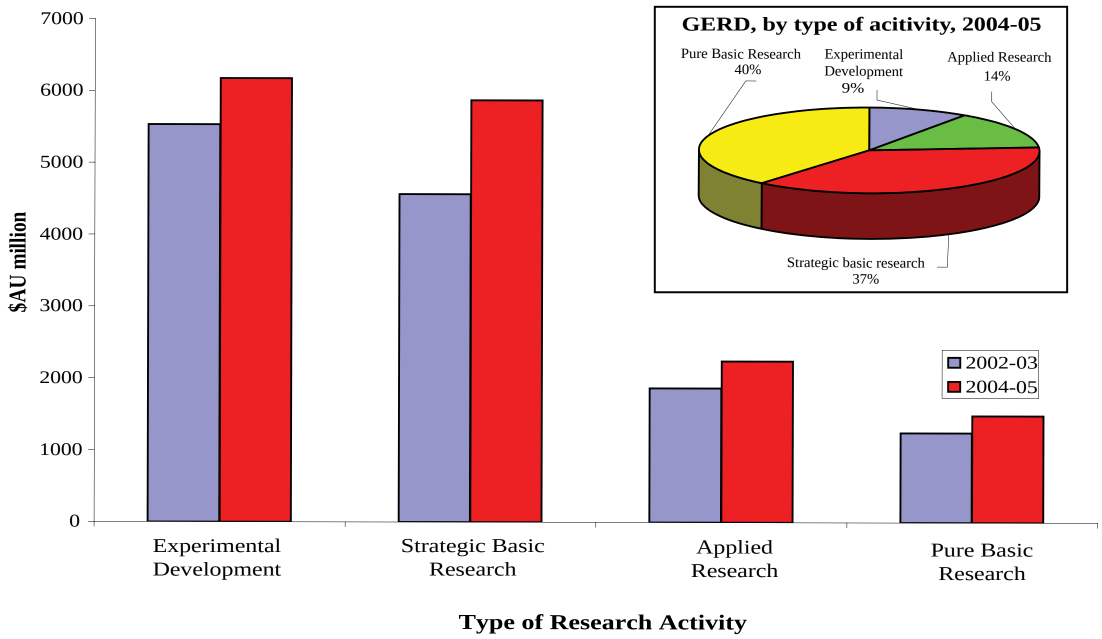
In 2004-05, the majority of GERD is invested in experimental development and applied research (Figure 3.10). All activities showed growth from 2002-03, with the strongest growth being applied research, which increased by 28.6%.

Figure 3.9: GERD by source of funds for 2002-03 and 2004-05, with percentage GERD by source of funds, 2004-05



Source: ABS, Research and Experimental Development All Sector Summary, 2004-05.

Figure 3.10: GERD, by type of activity, 2004-05



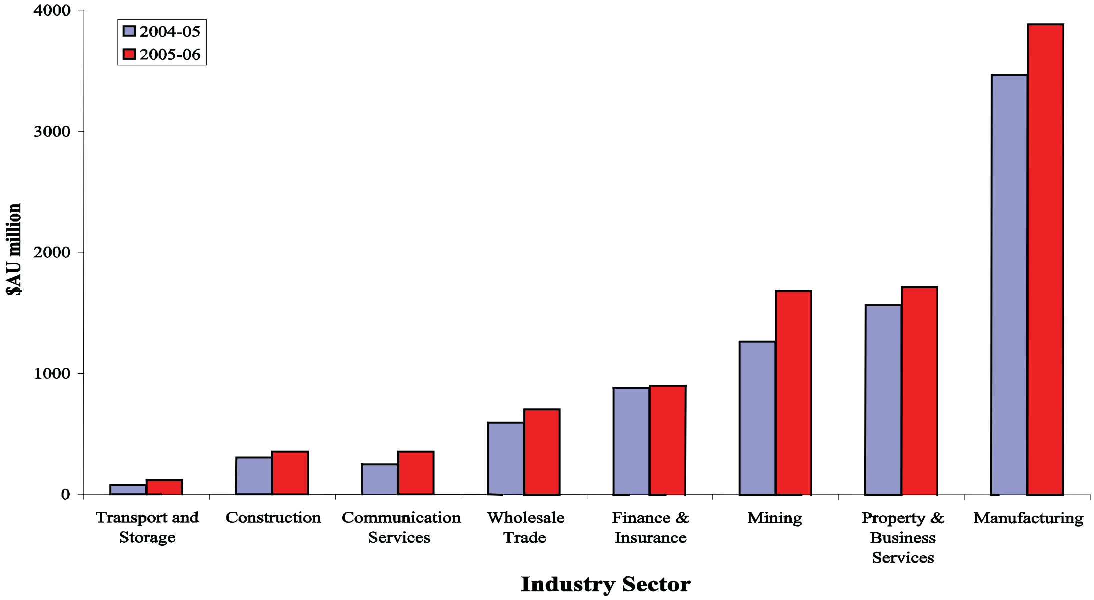
Source: ABS, Research and Experimental Development All Sector Summary, 2004-05.

The level of expenditure and funds on R&D have increased from 2002-03 to 2004-05 and are expected to keep increasing with the advent of the knowledge based economy. These figures highlight that businesses and institutions now view knowledge, R&D and innovation as essential requirements for economic growth.

3.3.2.1 Australian Industry Research and Development

In Australia, Business Expenditure on R&D (BERD) during 2005-06 was $10,080.7 million (ABS, 2007). This represents an increase of 16.6% over the 2004-05 value. The largest contributors to BERD are the manufacturing sector then the mining sector, and property and business services. Figure 3.11 shows that all industry sectors had an increase in BERD from 2004-05, with the mining sector increasing their expenditure by 33% and the manufacturing sector by 12%. In 2005-06, BERD as a proportion of GDP was 1.04%, which is below the OECD average of 1.53% and below the top OECD country (Sweden, 2.88%). This was the first time the BERD to GDP ratio exceeded 1.0% (ABS, 2007).

Figure 3.11: BERD, by industry sector, 2004-05 and 2005-06*

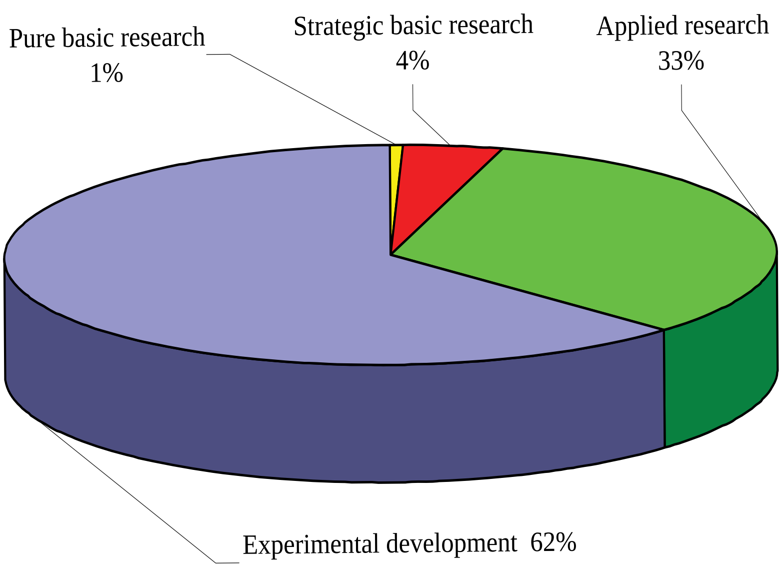


Source: ABS, Research and Experimental Development, Business, 2005-06.

Top 8 ranked by 2005-06 expenditure

The majority of the 2005-06 BERD was directed into experimental development (62.4%) and applied research (32.9%) and only small amounts are directed into pure and strategic basic research (4.7%), as seen in Figure 3.12.

Figure 3.12: BERD, percentage for research activity, 2005-06

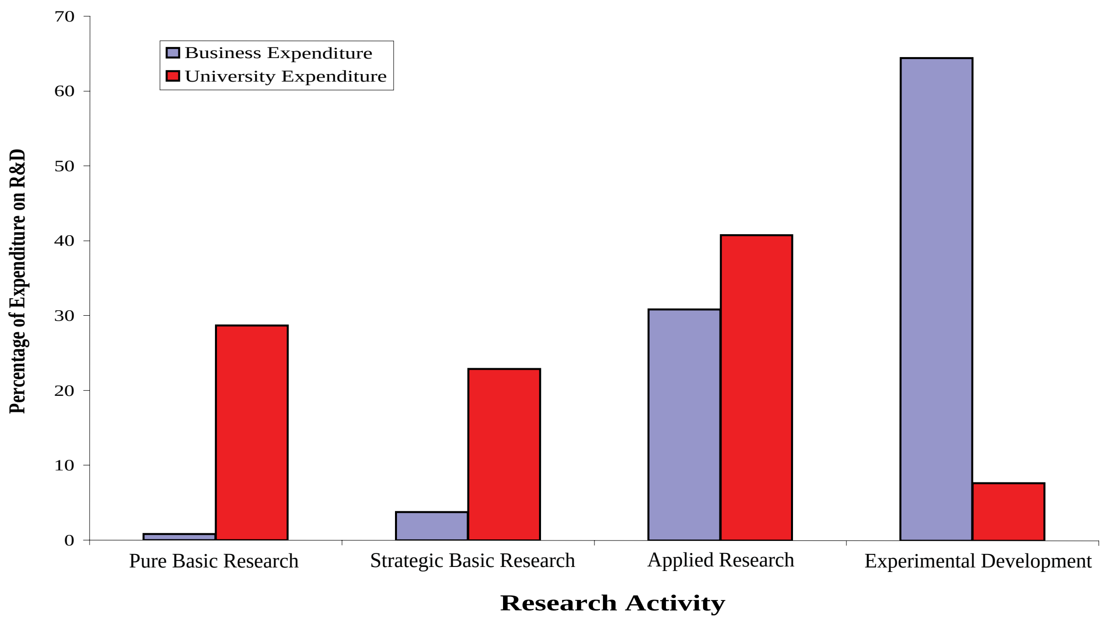


Source: ABS, Research and Experimental Development, Business, 2005-06.

This highlights that Australian businesses are consistent with overseas businesses and have a strong focus on experimental development rather than basic research (COA, 2003). In a comparison of expenditure on R&D for 2004-05, business expenditure is heavily skewed towards experimental development and applied research while university expenditure is spread between applied research, and pure and strategic basic research, with minimal emphasis on experimental development (Figure 3.13). This figure also reveals the different research objectives of industry and universities.

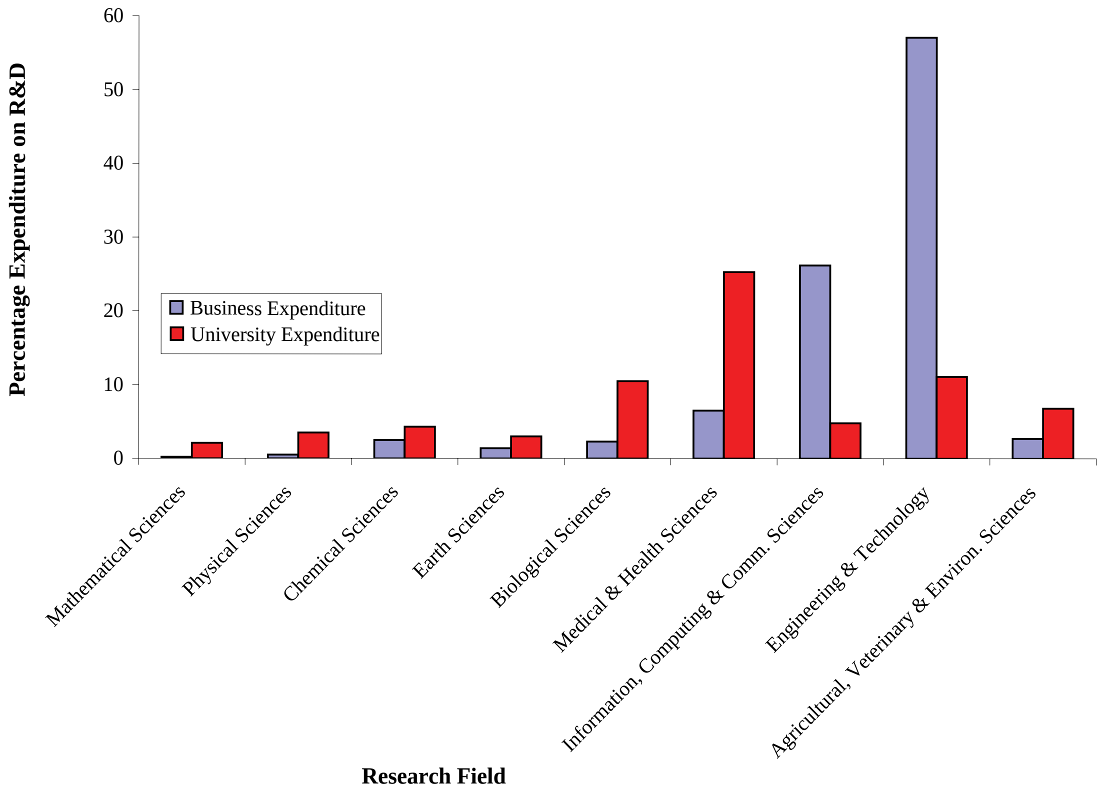
The other difference between the business and higher education sectors concerning R&D is the expenditure in different research fields (ABS, 2007). In 2004-05, Figure 3.14 shows that the main fields of research in the business sector were engineering & technology (57.1%), and information, computing & communication sciences (26.2%), while the main fields for the higher education sector were medical & health sciences (25.3%), engineering technology (11.1%) and biological sciences (10.5%).

Figure 3.13: Expenditure on R&D for both business and university, 2004-05



Source: ABS, Research and Experimental Development All Sector Summary, 2004-05.

Figure 3.14: Expenditure on R&D by research field for business and university, 2004-05. (Social Science Research Fields have been omitted)



Source: ABS, Research and Experimental Development All Sector Summary, 2004-05.

In relation to GDP, the manufacturing sector contributes 13% of GDP but accounts for 43% of BERD. Conversely the services sector contributes significantly less to BERD (47%) than its contribution to GDP (77%). This is expected as the manufacturing sector focuses its R&D on developing and improving new products, while the services sector mainly concentrates its R&D on knowledge and skills and how they are utilised within the business (COA, 2003).

The mapping Australian science and innovation report (COA, 2003) has suggested a number of factors that may explain Australia's low level of BERD compared to other nations:

- due to the large quantity of small companies that constitute the Australian industry structure, and the lack of large multinational companies.
- business focuses more on short-term survival which is routine in small companies.

- the lack of capacity of businesses to understand the significant benefits obtained from R&D and innovation in the knowledge economy.

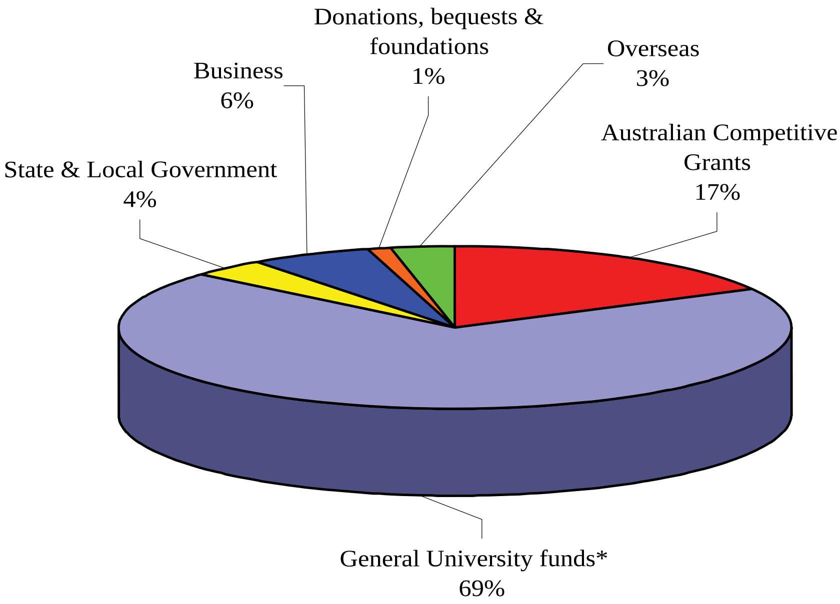
3.3.2.2 Australian University Research and Development

Expenditure on R&D in the Australian higher education sector (HERD) for 2004 was $4,283 million, which represented an increase of 24.9% from 2002 (ABS, 2006b). HERD as a proportion of GDP increased from 0.44% in 2002 to 0.48% in 2004, which is above the OECD average of 0.44% and is higher than Germany and the USA but lower than Canada and Sweden. As seen in Figure 3.13, the majority of HERD for 2004 was directed towards applied research (28.7%), pure basic research (22.9%) and strategic basic research (22.9%).

Figure 3.13 reveals the small amount of HERD that is directed to experimental development as compared to the large amount for BERD. The majority of funds for HERD for 2004 (Figure 3.15) were sourced from general university funds (69.2%) followed by Australian competitive research grants (17.2%). This contrasts with the small amount of funds sourced from business, state and local governments, and overseas (ABS, 2006b).

Industry and university expenditure on R&D are directed towards different research fields (Figure 3.14). Medical and health sciences account for 25% of HERD followed by engineering and technology, and biological sciences at 11.1% and 10.5%. This is expected as research performed in the medical and biological fields is mostly basic and applied research as opposed to the experimental development performed in the engineering and technology field. The major Australian states are all consistent with the Australian trend for science fields except for South Australia where 35.9% of HERD is directed towards medical and health sciences.

Figure 3.15: HERD, by source of funds, 2004



Source: ABS, Research and Experimental Development, Higher Education Organisations, 2004.

* includes other Commonwealth government funding not covered by the Australian competitive grants scheme

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3.4 University/Industry Interactions

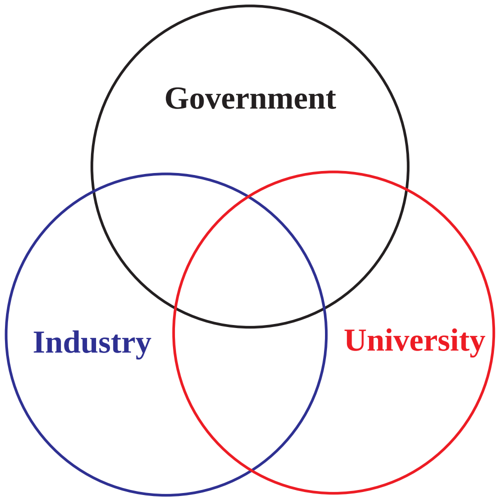
There has been an increase in collaboration between industry and university academics and researchers. Many OECD governments have been encouraging the increase of research links between universities and industry (Harman & Sherwell, 2002).

While industry only supports a small amount of university R&D, there is a belief that universities must look to industry for a greater share of their R&D support (Mansfield and Lee, 1996). The linkages between universities and private companies are critical for the flow of knowledge in a national innovation system, with Mansfield and Lee (1996, p. 1047) stating that "universities play a major role in originating and promoting the diffusion of knowledge and techniques that contributes to industrial innovations."

3.4.1 Triple Helix Model of Interaction

The triple helix model (Figure 3.16) was proposed by Etzkowitz and Leydesdorff (1997) and denotes that there are complex interlocking relationships between university, industry and government. These equal and interdependent institutional helices overlap each other and can assume each others roles. The boundaries between university and industry are in a state of flux, and they are both assuming roles and tasks that were once predominantly the province of the other (Etzkowitz and Leydesdorff, 1998).

Figure 3.16: Triple Helix Model of University-Industry-Government Relations



Etzkowitz and Leydesdorff (1997) state that three dimensions of the triple helix model exist at different levels of the knowledge and innovation process:

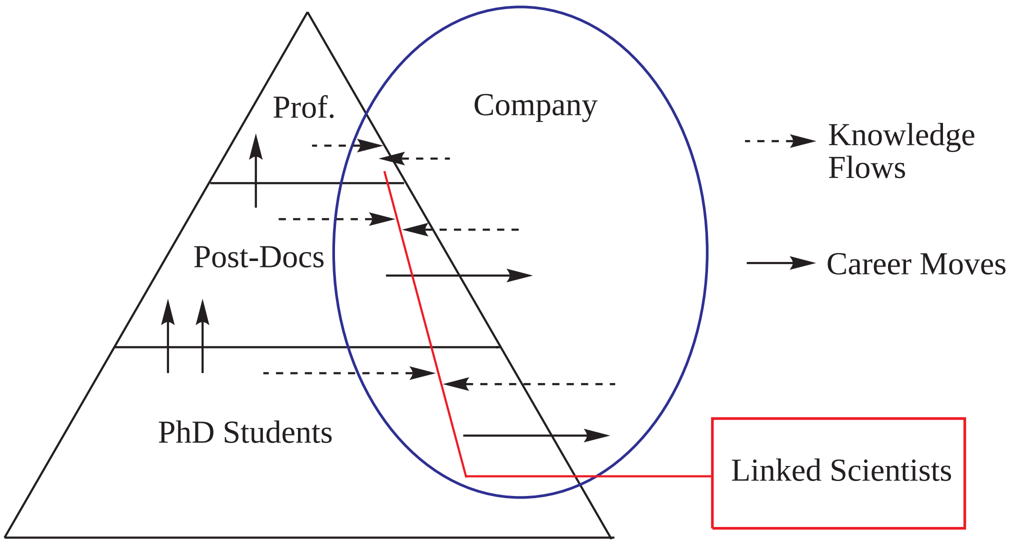
- internal transformation in each of the helices. These transformations can be links among businesses, new mission statements for universities and co-operation between different governments such as local, state and federal.
- the influence of one helix upon another such as the introduction of a government policy on industry or university, funding of university research by industry and the use of university findings by industry.
- the creation of new and complex trilateral networks and organisations due to the interaction of all three helices. These are developed for the purpose of forming new ideas for economic development and growth.

These collaborations are originating from industry and university and are encouraged by both regional and national governments for the purpose of stimulating innovation and economic growth through the development of a knowledge base.

The interaction of universities and industry has often been described by the indiscriminate term of ‘technology transfer’. This term implies that the university develops some type of technology based on their research and then conveys this to industry entrepreneurs. Meyer and Schmoch (1998) note that this one directional transfer of knowledge and subsequent value added is often the case between universities and SMEs within regions. This process is similar to the linear model of innovation and is actually very rare in reality.

Instead of this one-way transfer of knowledge and benefits from universities to industry there are other modes of interaction which allow for a bi-directional flow of knowledge between university and industry partners (Gibbons *et al*. 1994; Meyer-Krahmer & Schmoch, 1998; Schmoch, 1999). Bi-directional modes of interaction are contract research, collaborative research, consultancy, and informal contacts. The university researchers who engage in these interactions have been referred to as ‘linked scientists’ (see Figure 3.17) and are people who develop knowledge networks and possible career patterns that incorporate both academia and industry (Lam, 2007). Lam (2007, p. 995) uses the word ‘entrepreneurial to describe scientists “who make connections to business firms in their research, and who combine academic goals with knowledge application by building organisational ties between academic research groups and firms.”

Figure 3.17: A conceptual framework: 'Linked scientists in university-industry knowledge networks' (Lam, 2007)



There are three categories of university researchers who perform the role of 'linked scientists (Lam, 2007) being:

- 'entrepreneurial' professors – they are the essential focal points of companies' links with universities. They are the scientists who take an active role in both the scientific and business sectors. They build links through collaborative research, consulting and student placements. They develop through their career what Etzkowitz (1998) describes as a 'dual cognitive mode' in their research, focusing both on basic research (scientific research) and applied research (application of their knowledge). These professors play a vital and essential role in connecting universities with industry.
- post-doctoral researchers – are researchers who are usually employed for a duration on an industry collaboration. They represent a source of flexible scientific labour (Lam, 2007) which can be shared between universities and industry.
- doctoral students – are students whose skills are developed by both universities and industry through industry scholarships or industry-university training programmes. These programmes strengthen the links between industry and universities and create a scientist who is able to operate in both academic and industry.

Van Dierdonck *et al.* (1990) stressed that despite a number of different mechanisms for university-industry links, a research group professor or head is the still the key figure, as they are able to create funding and momentum for the group by seeking these external links and funding.

3.4.2 Industry Funded University Research

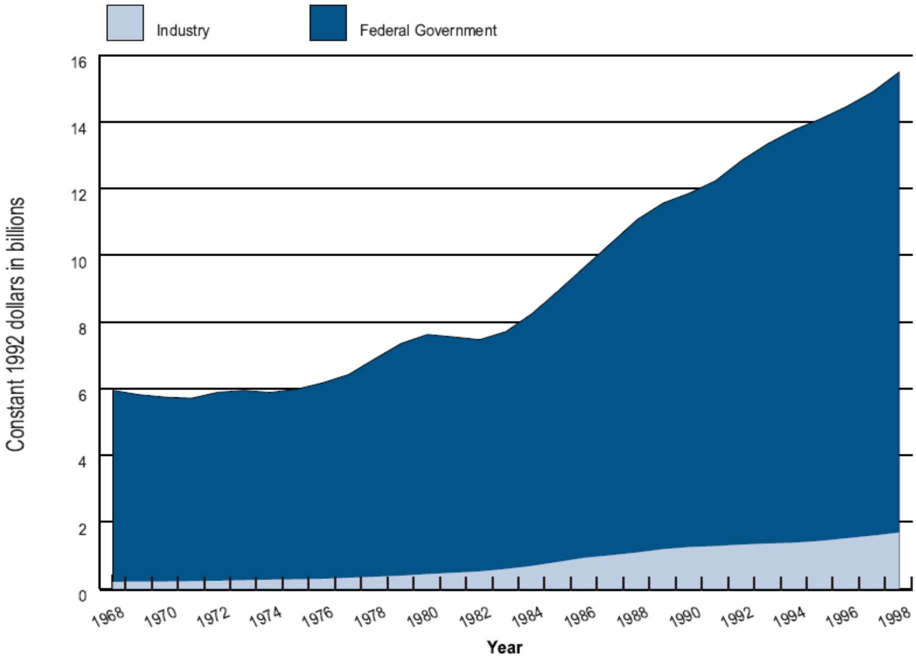
The importance of those previously mentioned bi-directional interactions are highlighted in Table 3.2 which shows that UK companies which use universities as a partner as a source of information and research tend to be more successful than companies that don't (Lambert, 2003).

Table 3.2: The relationship between business performance and university collaboration (Community Innovation Survey, 2001, as per Lambert, 2003)

	Increased range of goods and services	**Opened new market or increased market share**	**Improved quality of goods and services**	**Reduced unit labour costs**
Enterprises which do not use universities as a partner	**42%**	**40%**	**46%**	**33%**
Enterprises which use universities as a partner	**82%**	**81%**	**85%**	**65%**

Even though university-industry links are important in this changing economy, there are still reasons why industry and universities do not collaborate. Lee (1996) reports that industry sponsored research at colleges and universities in the USA, has grown at a substantial rate, with funding being seven times greater (in constant dollars) for 1997 than in 1970. Industry support for university R&D is still small compared to federal funding (Figure 3.18).

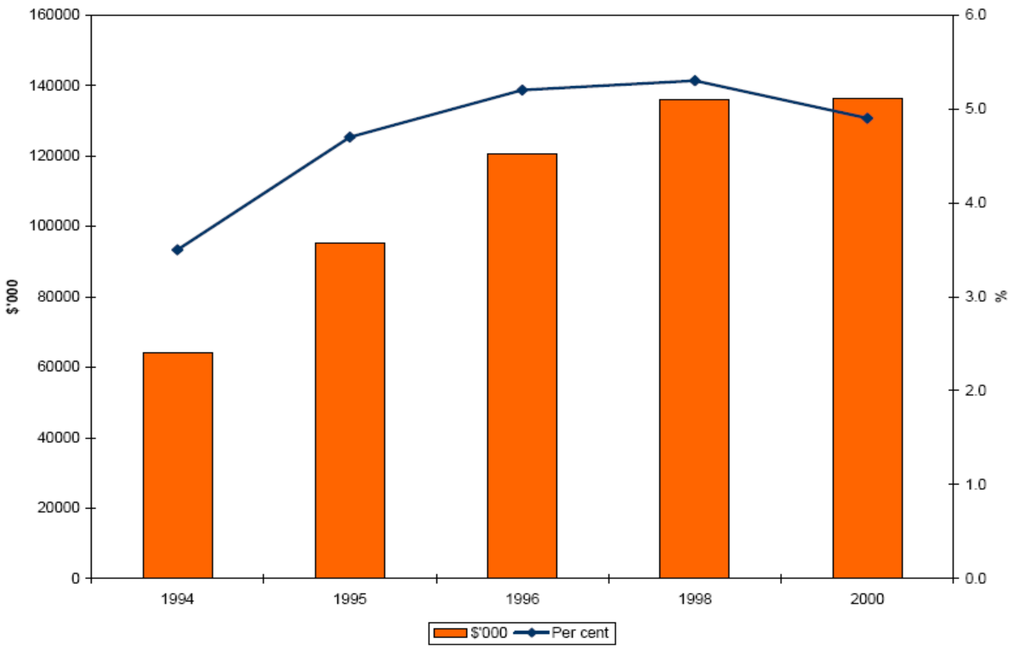
Figure 3.18: Industry and Federal support for university R&D, USA (ACE, 2001)



In 1998, nearly $2 billion or 9% of research performed at USA universities was sponsored by industry, while federal support amounted to well over $13.5 billion (ACE, 2001). In the same year industry spent nearly $145 billion on its own R&D. This highlights the high level of funds invested by industry into R&D, with industry support for university research predicted to double over the next decade.

In Australia, industry supported nearly $140 million or 5% of research at Australian universities, in 2000 (Figure 3.19). This was below the OECD average of 6.2%, with the majority of industry support going to medical and health sciences, biological sciences and engineering and technology (Commonwealth of Australia, 2003). Collaborations between university and industry are not increasing at the same rate as university and government department collaborations, and are due to barriers that exist due to the different objectives, cultures and ideals of industry and universities.

Figure 3.19: University research supported by industry, Australia, 1994-2000 (COA, 2003)



Hall *et al.* (2001) found that a main reason or barrier for university-industry collaborations is the issue of intellectual property (IP) rights. The issue of IP is a major barrier that has to be overcome for a successful linkage to occur. Another major barrier identified by Pavitt (2003) was the organisational and cultural differences between industry and universities. Companies complained that university researchers and academics had little regard or understanding of the urgent deadline of business.

Even with barriers present, all universities are able to refer to successful collaborations between themselves and industry partners. Lööf and Broström (2006) have suggested that despite the importance of university-industry links, knowledge on this area is limited and most research has been focused on the USA. The experiences of these links in the USA's economy are often consistent with findings from other countries.

3.4.3 Types of Industry-University Links

The links between universities and industry consist of a sub set of many different relationships. In the working together, creating knowledge report (ACE, 2001) there are six main mechanisms through which universities and businesses can have links:

- collaborative research – research partnerships are encouraged through partial government funding
- sponsored research – companies directly fund university research
- consortia- groups of companies and universities engage in various research activities of common group effort
- start-up companies – usually involves a university faculty
- technology licensing – licensing of university patents to companies to produce a commercial product.
- exchange of research personnel and materials – used to increase research performance through personnel and material transfers.

The first three listed mechanisms are fully collaborative in nature, in that there is a greater interaction between the university and industry partners.

A report by the ARC (2001), mapping the nature and extent of business-university interaction in Australia, details five key interactions between industry and business:

- knowledge interactions – provide the means through which information, research and knowledge moves between partners in formal or informal relationships.
- business interactions –structured arrangements involving funds.
- structural interactions – organisations that provide and encourage university-business interaction.
- geographical interactions – build links through co-location and sharing of facilities between university and industry.
- government support – interactions assisted through government advisory arrangements, funding and research support.

The different means for each of five key interactions are shown in Table 3.3.

Table 3.3: Classification of university-business interactions (ARC, 2001)

Knowledge Interaction	Business Interactions	Structural Interactions	Geographical Interactions	Government Support
Strategy and Planning	Corporate gifts and bequests	University school, faculties, departments	Technology precincts	Advisory councils and committees
Information transfers	Corporate sponsorship	University research institutes and organisations	Business incubators	Research performing institutes and organisations
Skill transfers	Cooperation	Research centres	Science and technology parks	Research funding councils and corporations
Skill enhancement	Collaboration	Cooperative Research Centres	Industry clusters	Commonwealth government departments
Knowledge enhancement	Contract and consultancy	Technology transfer companies		State Government departments
Access to facilities and capability	Commercial participation	Joint venture companies		
Commercial knowledge exploitation	Commercial partnership	Business Associations		
	Commercial competition	Personnel interchange		
		Personal networks		

3.4.4 Collaboration Advantages

University and industry collaborations have being increasing and are likely to continue increasing in coming years. Linkages between university and industry serve the interests and offer rewards for both participants (Buys & Bursnall, 2007). This symbiotic relationship allows university academics to advance their research and businesses to market new products and processes.

With all relationships between two or more parties there exists advantages and disadvantages to the parties. Lee (2000) compiled a list of reasons for universities and industry to collaborate together from relevant literature on university-industry collaborations. These reasons or motivations have been further researched and documented by Harman (2001); Shane (2002); Siegel *et al.* (2003); Hurmelinna (2004) and Azagra-Caro *et al.* (2006).

3.4.4.1 University Advantages

There are a variety of reasons or advantages for universities to collaborate with industry. The major advantages that have arisen from research conducted by the above mentioned authors for universities to collaborate with industry are to:

- obtain extra funds for academic research
- secure funding for laboratory equipment and research assistants
- enhance career and employment opportunities for students
- further the university's community mission
- identify significant, interesting and relevant problems
- look for business opportunity
- test the practical application of academic research

Lee (2000) and Harman (2001) determined that the main reason or advantage for university academics to collaborate with industry is to gain access to extra funding. Extra funds are used by academics to enhance their research by recruiting more research assistants and purchasing new lab equipment. It was also discovered that academics who received funding from industry, also held a number of government ARC or NHMRC grants (Harman, 1999). Lee (2000); Shane (2002), and Hurmelinna (2004) found that understanding the practical application of academic research was an advantage for industry collaboration. Harman (1999) in a study on industry funded researchers in Australia determined that nearly 40% of researchers believe that industry links enhance career opportunities for students and increased the rate of applying basic research outcomes to industry problems. Harman (1999), Gulbrandsen and Smeby (2005) noted that academics who have links with industry perform better concerning publications and entrepreneurial activities than academics who don't have industry links.

Harman (1999) notes that increased publication levels are due to the greater number of PhD students and post-doctoral fellows that industry linked academics have. Academics with industry funding are more likely to collaborate with other businesses and universities along with colleagues in their own university and department (Gulbrandsen and Smeby, 2005). Another benefit academics view when collaborating with industry is that industry funding enhances the university's or faculty's prestige (Harman, 1999; Lee, 2000; Hurmelinna, 2004).

An interesting reason proposed by Laukkanen (2003) concerning university-industry links, is the concept of 'political pressure'. This is the pressure that is applied to universities by governments to collaborate with industry and become a driving force for regional innovation and economic growth. Harman (2006) reported that science and technology academics view industry-university links as having positive effects in terms of attracting additional funding, enhancing career opportunities and increasing the university's or department's prestige. These views are shown in Table 3.4, which also highlights that there are only a small percentage of respondents thought industry links had a negative aspect.

Table 3.4: Percentage of Science and Technology academics who said 'agree' or 'strongly agree' to the following statements in regards to Industry Links (Harman, 2006)

Provide rsources for research unavailable elsewhere	62.8
Enhance the university's or the department's prestige	50.5
Lead to an emphasis on 'quick fix' solutions rather than long-term basic research	46.1
Result in the decreased publication productivity for the researchers involved	35.2
Diminsh scholarly prestige of involved researchers	19.8
Enhance career opportunities for students	68.7
Open new and promising avenues of research	54.9
Contribute to breakthroughs in basic science	24.5

Research by Harman (1999) determined that academics who collaborate with industry, spend more time undertaking teaching and professional activities and have better publishing records. Further research by Harman (2001) suggested that science and technology academics consider university-industry links to be functioning well in the major Australian universities.

There is evidence that there are significant benefits that can be obtained from university-industry links for academics, research students and universities, but Harmann (2001) notes that academics and universities should do more to document the extent of these benefits and the contributions they make to university research activities. Universities are now developing internal positions to assist academics in finding new collaboration partners based on academic research interest, university research strengths and industry research opportunities. These new positions are expediting the process for industry partners to identify the correct academic to collaborate with. Carayol (2003) identified that matching specific university talents with potential industry partner requirements allows for different collaborations to occur. Increasing the levels of industry collaboration could be further enhanced through promotion processes that give appropriate credit to university researchers who collaborate with industry.

President of the University of California, Richard Atkinson (ACE, 2001, p. 10), best summarised university involvement in industry collaborations by saying:

> *"We seek cooperative research relationships with industry not simply to generate royalty revenue and economic growth, but to create relationships with industry that will help faculty in pursuing their own research and in training graduate students."*

3.4.4.2 Business Advantages

The reasons or advantages for industry to link with university academics in a collaborative arrangement are to:

- gain access to new knowledge, technology and research
- solve a specific technical problem
- conduct "blue sky" research in search of new technology
- provide a route to recruit university graduate
- maintain an ongoing relationship with the university or academic
- reduce R&D costs
- risk share for basic research

The biggest advantage or motivation for industry to collaborate with universities is to access new technologies and knowledge (Hurmelinna, 2004; Meyer-Krahmer &

Schmoch, 1998). Acquisition of new knowledge and technologies allows a business to maintain a competitive advantage of its competitors. This advantage allows a business to innovate new products and processes that it might have been impossible without the university collaboration.

Another major reason for industry to collaborate with universities is to reduce business R&D costs and share the risk involved in basic research (Hall *et al.* 2003). As Australian industry is predominantly SMEs, they don't have the funds to perform extended R&D or basic research, so collaboration with a university will allow the business to gain two benefits through accessing new knowledge, and sharing the cost of employing researchers and equipment. Hall *et al.* (2003) also discovered that collaborations with universities had a stabilising effect whereby the research project was less likely to be halted as there were other parties involved in the project.

3.4.5 Barriers to Links

There are potential obstacles or barriers that prevent industry collaborating with universities successfully. Van Dierdonck and Debackere (1988) categorised these barriers which are listed below in Table 3.5. By being able to categorise and understand these barriers there may be possible procedures which can circumvent the barrier and allow for a successful collaboration. Van Dierdonck *et al.* (1990) noted that there are cultural differences between industry and academia and so they find it hard to collaborate with each other.

Cultural differences are centred around differing missions where industry are attempting to maximise profit and increase the businesses value, while the university mission a research and science and in turn, advance society. Pavitt (2003) and Hurmelinna (2004) both noted that another cultural barrier was the difference in language and assumptions. They found that industry often criticised, that universities operate on an extended time line and that they didn't understand that industry requires rapid results.

Table 3.5: Barriers affecting university-industry collaborations

Cultural Barriers	Different missions and goals Different and confliciting interests on IP and publishing results Different language and time understandings
Institutional Barriers	Different work and research nature Different understanding of what R&D is Structural change of methods and responsibilities of the company and university
Operational Barriers	Inadquate project management Difference in direction of the project Lack of funds from the industry partner to complete the project

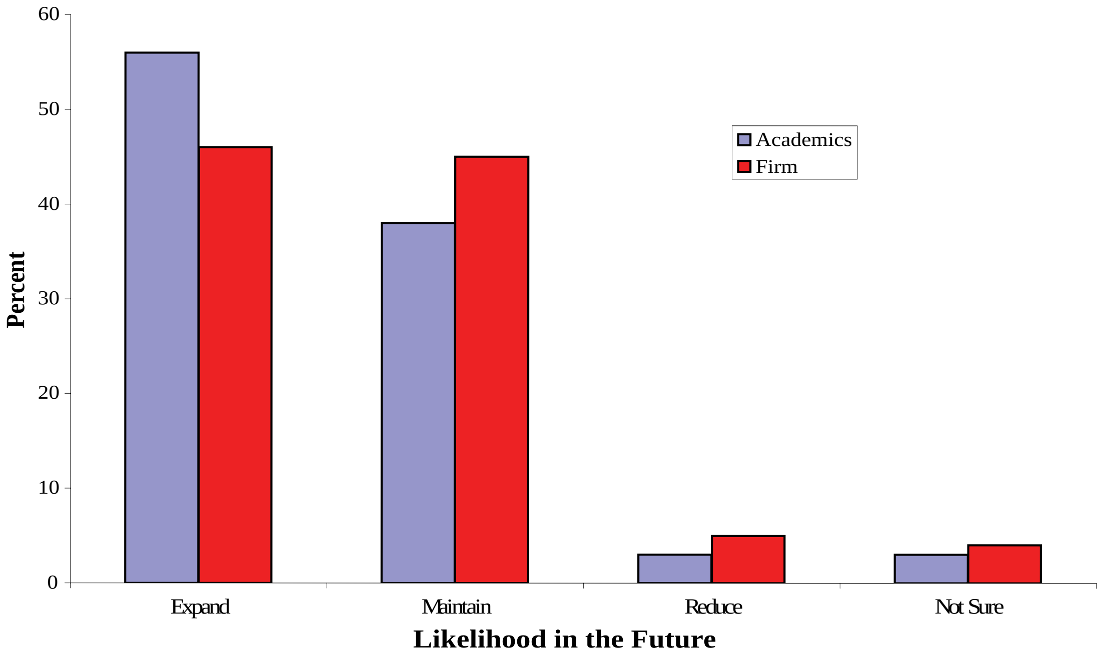
Adapted from Rohrbeck & Arnold (2006) and Van Dierdonck & Debackare (1998)

Hall *et al.* (2001) reported that IP issues were a major barrier for collaboration. These issues were focused on the point that companies believe that having secrecy and IP of the R&D results allows them to maintain a competitive advantage over their competitors while universities need to publish these results, to enhance their reputation while the research is still novel. This barrier of dissemination of results was also reported by Kruss (2006) in her research of university-industry partnerships in South Africa. Morgan and Strickland (2001) discovered in a study on university – industry collaborations in the fields of science and engineering that universities and faculties were willing to forgo their ability to publish results for commercialising results and patent protection of their results.

Harman (2001) found that Australian academics found that they were concerned that university-industry links threatened research autonomy and increased time required on commercial. Academics understand they need to compete to attract industry funds for research collaborations, but at the same time they are guarding against becoming just totally dependent on contract research, as they feel indebted to the industry partner due to this dependence on funding.

Even with all the barriers, the levels of university-industry links are significant and increasing due to the considerable benefits they offer to academics and businesses (Gulbrandsen and Smeby, 2005, Lee 2000; Harman, 1999). Lee (2000) found that 94% of faculty academics and 91% of industry managers think they are likely to expand or at least maintain their level of collaboration (Figure 3.20).

Figure 3.20: Likelihood of future research collaboration between university faculty and firms (Lee, 2000)



Morgan and Strickland (2001) determined that science and engineering academics wanted the same (20%) or greater (76%), involvement by industry in their research. For university-industry collaborations to be increased, universities and industry have to work together to overcome or reduce the barriers due to their cultural and systemic differences (Lööf & Broström, 2006; Kaufamann & Tödtling, 2001; Harmann, 2000, and Lee, 2000).

3.5 Government Incentives

There exist many different programs and policies that are implemented by national, state and local governments to increase innovation and R&D. These programs and policies differ from country to country and region to region. These policies and programs are implemented as governments know that innovation and R&D are the key drivers of economic growth.

In the USA, the introduction of the Bayh-Doyle Act in 1980 increased industry funding of university research, as it allowed universities to patent findings of government sponsored research. Before this act, universities were being granted about 100 patents per year, but this number had increased to 500 by the end of the 1980's. Researchers thought this act might shift the nature of university research from basic towards applied research but there has been minimal evidence to suggest this has occurred (Mowery & Sampat, 2005). In Australia, programs and policies to increase R&D and innovation were implemented after various government reports in the 1980's highlighted weaknesses in Australia's capacity to innovate and perform R&D (Harman, 2002).

The Australian Federal government has introduced a variety of grants and programs to increase industry R&D. A major grant is the R&D tax concession, which is a broad-based, market driven tax concession that allows companies to claim a tax deduction of up to 125% of expenditure incurred on R&D activities. The commercialising emerging technologies (COMET) grant allows spin-off and early growth companies to successfully commercialise their innovation. There also exists, individual grants for the automotive, pharmaceutical, textile, renewable energy industries.

For a list and description of significant Federal grants see Appendix C. These grants and the new business perception of the significance of innovation and knowledge, has seen BERD for Australia increase each year.

Other initiatives introduced by the government to combat Australia's weak innovative capacity were aimed at encouraging links between universities and industry. The major initiative was the formation of the CRC program in 1990, which gathered together researchers from universities, government laboratories and industry in long term collaboration, to support R&D, and education and training.

ARC Linkage grants were introduced in 1990, as a scheme that supports collaborative R&D projects between higher education organisations and other organisations, including industry, to enable the application of advanced knowledge to problems. The other significant program was the International Science Linkage (ISL) which supported Australian public and private scientists, to collaborate with international partners on leading edge science and technology projects. The introduction and funding of these initiatives by governments reinforces the triple helix model proposed by Etzkowitz and Leydesdorff (2000) that university, industry and government all play an essential role in innovation and economic growth of regions and nations.

The difference between the levels of university-industry collaborations in the USA and Australia is that Australia has not enacted any law comparable to the Bayh-Dole act and incentives for non-government funding of university research is weaker than those in the USA. These could be addressed by the Federal Government by implementing tax breaks for non-government funding of links and passing an act that allows Australian universities to seek patents on their research (Moses III *et al.* 2002).

3.6 Chapter Summary

This chapter highlights the importance innovation and R&D plays in a knowledge based economy. It has been shown that knowledge is now viewed as a critical asset for a business and the acquisition of this knowledge allows for a business to maintain a competitive advantage over its competitors.

Collaborations between industry and universities have increased and these linkages are critical for the flow of knowledge in a national innovation system. It has been identified that universities play a critical role in the national innovation system and in regional economic development. They play a major role in originating and promoting the diffusion of knowledge to industry. The university researchers who interacted with industry are referred to as 'linked scientists' and are academics that developed knowledge networks that incorporate both academia and industry. The triple helix model of interaction allows for an understanding of the complex interlocking relationships between industry, university and government.

R&D performs a critical and crucial role in science and companies now view R&D and innovation as critical for their survival and growth in the knowledge based economy. They need to acquire knowledge and technology to remain competitive in a global economy. Universities primary role is to undertake basic research and produce educated graduates, but lately an expanding role within universities has been to perform industry aligned applied research. Compare to the OECD averages, Australia's expenditure in higher education is higher, while business expenditure on R&D is lower.

Collaborative research, sponsored research and consortia are fully collaborative mechanisms by which university and industry interact. The interaction of industry and university has advantages for both partners. Industry advantages are to gain access to new knowledge, technologies, solve specific problems, reduce R&D costs and risk share for basic research. Advantages for university academics are to obtain extra funds for academic research, enhance career and employment opportunities for students, secure funding for laboratory equipment and further the university's community mission.

Barriers preventing these links must be overcome to increase the levels of these links. Major barriers have been identified as cultural differences between industry and academia, issue of intellectual property and the dissemination of results. Despite these barriers, research has shown that academics and industry managers who participate in these links are likely to maintain or expand their level of collaboration.

Government programs and grants have been introduced to increase the levels of collaboration. In the USA, the major driver for the increase of university-industry links was the introduction of the Bayh-Doyle Act in 1980. In Australia the introduction of the R&D tax concession and other specific grants has increased R&D in business.

The implementation of the CRC program and ARC Linkage grants has increased the level of interaction and collaboration between industry and academia.

This chapter has provided an overview of knowledge, R&D and industry-university links. It has revealed characteristics that can be further researched to understand why industry collaborates with academia and an understanding of the nature and extent of industry links from an academics point of view from differently aligned universities. Chapter Seven will be dedicated to the analysis of industry-university links and determine the nature, levels, advantages and means of improving collaborations between universities and industry.

Chapter Four

Clusters

4.1 Introduction

The growth of the advanced manufacturing industry is in part dependent on innovation and knowledge. Increasing these levels can be achieved through collaboration with suppliers, buyers, competitors and research institutions. Industry classification of businesses by their inputs and outputs does not highlight the important and critical relationships that occur between businesses to increase economic growth. It is these relationships that cause development variation for different industries and regions. The importance of inter-business relationships provides the foundation for the utilisation of clusters and cluster theory to understand the advanced manufacturing industry in Adelaide. This chapter will highlight the differing views on clusters and describe how the concept of industry, location, clusters and clustering effect not only business growth but regional and national economic development.

This chapter discusses the literature on clusters and in particular focuses on the possible identification of different linkages within clusters. The chapter begins by summarising the different definitions of clusters, the evolution of clusters and the cluster lifecycle. Different cluster types and cluster models are then described. Different examples of International and Australian clusters and the use of clusters for regional development are discussed. The chapter then focuses on the different types of relationships and linkages within clusters. The final section of the chapter discusses with possible advantages and disadvantages of a business being located within a cluster, then a chapter summary.

4.2 Clusters

Tödtling (1994) notes that there seems to be a paradox for economic development in the sense that globalisation is causing businesses to act in response to a world market while within the global knowledge economy, regional environments are having an increasing importance for the competitiveness of businesses. This idea was reinforced by Porter (1998b, p.77) who stated that:

> *"… the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, and motivation that distant rivals cannot match."*

The origin of the concept of clusters can be traced back to Marshall's (1920) identification of different industrial districts in England. Governments and researchers are rapidly becoming more interested in the concept of clusters and the role clusters play in national and regional economic development and growth (Porter, 1990, 1998; Steiner, 1998; Feser & Bergman, 2000; Cooke, 2002; Enright, 2003).

In this study, the concept of clusters is being utilised as a tool to identify and document linkages and relationships in the advanced manufacturing industry in different regions within Adelaide. The understanding of these business-business and business-university relationships and linkages will create an understanding of specific regional advanced manufacturing clusters which will be used to influence policies to enhance linkages between industry and universities and to further develop the region.

4.2.1 Definition

Many different definitions of the term 'clusters' exist, and the meaning of the word takes on different importance and meaning for economic and industry development researchers and practitioners. This means that cluster models and theories have been developed from a range of definitions and those differences between these models and theories are based on the researcher's perceptions. Doeringer and Terkla (1995) suggest that the term cluster is being used in ad hoc ways since it causes government policies to focus on single industry type and so miss important and essential linkages among businesses that are spread across different industry types and research institutions. The following discussion highlights the different definitions of clusters and the difference between these and other terms that are associated with clusters.

The term cluster was initially used by Czamanski (1974) in describing groups of industries linked through formal production ties excluding their geographic location. Czamanski and Ablas (1979) then used the term to identify different industrial groupings, linked by the movements of products and services. The term was then used by Porter (1990) in a similar context as Czamanski except that Porter's definition now included the recognition that clusters often have a geographic facet attached to them. The following definition developed by Porter (1998) has become the most widely used and quoted in literature:

> *"…a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities."*

Although this definition is the most widely used among researchers and economic practitioners, practitioners suggest there is no absolute definition of a cluster. Consequently, it is acceptable to choose a definition that best fits or reflects the research that is being undertaken. As this study is centred on the advanced manufacturing industry, which doesn't have a clear ANZSIC characteristic and is comprised usually of SME's, the definition of clusters used in this study is best reflected by Rosenfeld's (1997) definition which is:

> *"…a cluster is very simply used to represent concentrations of firms that are able to produce synergy because of their geographic proximity and interdependence, even though their scale of employment may not be pronounced or prominent."*

This definition deviates from other cluster definitions which focus on national economic competitiveness. It therefore allows for the definition of small clusters comprising of businesses that are not large employers or have a specific recognisable industry definition. This definition of clusters is broader than that specified in ANZSIC codes, so that the use of this term allows one to capture important linkages, complementarities and spillovers in terms of technology, skills and knowledge across different businesses, industries and research institutions. Using Rosenfeld's definition enables this study to recognise, identify and understand the small advanced manufacturing industry clusters located in different regions of Adelaide.

4.2.2 Cluster Concepts

The concept of clusters dates back to Marshall's (1920) work on specialised industrial locations and researchers have agreed that the concentration of firms in a particular location leads to specific economic advantages such as increasing returns to scale due to the pooled skilled labour, local markets and easy interchange of skills and knowledge. This work was further enhanced by Weber (1929), who researched patterns associated with industrial co-location and agglomeration economies. This underlying concept of agglomeration economies forms an essential part of the development of cluster theory (Martin & Sunley, 2003).

In their book the *Second Industrial Divide*, Piore and Sabel (1984) brought attention to the success of industrial districts within Italy. This attention on industrial districts, along with Harrison's (1991) description of Italian industrial districts, attracted researchers to focus on location, social structures and history in relation to economic development and regional competitiveness. This understanding of industrial districts and agglomeration economics was enhanced by Porter's work in *Competitive Advantages of Nations* (1990), were he developed the "Diamond of Advantage" framework which popularized the concept of industry clusters and allowed economic practitioners around the world to use clusters as a means to enhance the competitiveness of regions. In his Diamond Model, Porter identified four key determinants of industry competitiveness: factor conditions; related and supporting industries; industry strategy and structure, and home demand conditions. This lead to a claim by Porter (1990) that a region's competitiveness is based on the competitiveness of the industries located within that region and that competitiveness is improved if an industry is embedded in a deep interactive network with other industries and institutions. This implies that clusters are dynamic in nature and the interaction between industries, businesses and institutions within the cluster are constantly changing. Rosenfeld (1997) incorporated this emphasis on the importance of interactions within an expanded cluster definition:

"… a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue, that share specialized infrastructure, labour markets and services, and that are faced with common opportunities and threats."

4.2.3 What is a cluster?

The literature appears to point towards a basic definition of a cluster but there is limited consensus on how to define and describe an industry cluster. A basic definition by Doeringer and Terkla (1995, p.225) states that a "cluster is a geographical concentration of industries and businesses that gain economic and performance advantages through co-location." Clusters encompass an assortment of industries and businesses that are linked through vertical and/or horizontal, formal and/or informal relationships. Many clusters include competing businesses, suppliers, government bodies, trade associations and research institutions. Vertically integrated clusters consist of industries that are linked through buyer-seller relationships, while horizontally integrated clusters consist of industries which use a common technology platform, share a common product market and/or require similar resources such as skills, knowledge and materials. Porter (1998b, p.88) noted that "the mere co-location of companies, suppliers, and institutions creates the potential for economic value; it does not necessarily ensure its realization."

Clusters occur in many industry types and are present in large and small economies, rural and urban areas and at national, state and regional levels (Rosenfeld, 1997). Porter (1998b) found that clusters rarely conform to a country's standard industrial classification and so statistics from these classifications fail to recognize important players or relationships. Porter determined that in Massachusetts, a cluster of nearly 400 companies in medical devices had remained unnoticed due to it falling under the larger and overlapping industry categories of plastic products and electronic equipment. It is only now that business executives are working together on issues to benefit the businesses within this cluster. The boundaries of clusters are dynamic and are continually evolving as new businesses and industries emerge, established industries shrink or decline and local institutions develop and change.

Relationships between businesses and industries are fundamental to competition, productivity, prosperity, innovation and business formation and growth. It is the emergence of technological and market developments that give rise to new industries and businesses create new linkages and change already served markets. The concept of clusters and co-location suggests that some competitive advantage resides in the locations of businesses and not within the business or industry itself. Many businesses within clusters share common requirements, opportunities, constraints and threats to increasing productivity and innovation. In some cases the growth and health of the business is partially due to the development and growth of the cluster and region. Public and private investments to improve a cluster or region, as opposed to particular industry, benefit more businesses located within that particular cluster or region.

4.2.4 Geographic Concentrations

There exists a variety of different types of intra- and inter-industry relationships and linkages that have allowed for the evolution of clusters. These relationships have been discussed in literature as means by which geographic concentrations of businesses can derive economic advantage and increase regional economic development. These types are best described under the following headings:

- Agglomeration Economics
- Networks
- Industrial Districts
- Creative Milieus

4.2.4.1 Agglomeration Economics

Agglomeration economics describes the benefits that businesses obtain from being located in close proximity to one another. Agglomeration occurs where the concentration of an industry is above that which is considered normal in that industry (Devereux *et al*. 1999). Early research into agglomeration economics and co-location patterns by Weber (1929) proposed three key factors for co-location, being economies of scale, transport cost differentials and labour cost differentials.

The understanding of why there are concentrations of economic activity or businesses underpins the concept and discussion of clusters. The underlying reason for agglomeration economies is the cost reductions or economies of scale that the individual business can achieve. Blair (1991) notes these cost reductions as the following:

- *Per Unit cost reductions* – occur internally within the business through the spreading of fixed costs, purchasing savings and increased division of labour.
- *Localisation economies* – occur externally to the business but internally to the industry type, as a co-location of common businesses can increase the supply of, and decrease the cost of, common factors such as land, energy, rates, transportation, labour and capital.

Harrison (1991) notes, that it is these external benefits of pooled infrastructure and labour that cause individual business costs to be reduced in co-locations. These cost reductions are often associated with large firms but are also seen when small firms co-locate (Marshall, 1920; Harrison, 1991). Rosenthal and Strange (2003) determined that small firms experience a larger agglomerative effect than large firms if there is a competitive co-location environment. Smaller firms agglomerate together and also co-locate around larger firms to take advantage of possible knowledge spillovers which are sometimes the impetus needed to initiate cluster development. If the extent of technology transfer or knowledge spillover is related to geographical proximity, then a firm needing to exploit knowledge spillover needs to be co-located near the core of knowledge or technology (Baptista & Swann, 1998).

The creation of new technologies and products is increasingly becoming a collective effort between firms, universities and other institutions and it is these collective interactions that are often seen as facilitating the development of regions and industry clusters.

Blair (1991) noted that there exists another cost reduction factor due to co-location: urbanisation economies. These are economies where cost reductions are gained due to improved infrastructure and expanded local market opportunities as a result of increased economic activity in the urban area.

Literature suggests that the agglomeration and co-location of businesses links economic and regional development theories together. Scott (2000) acknowledges that agglomeration does not fully explain or account for how regional and economic development combines to create vibrant and dynamic clusters. For agglomeration economics, the level of economic understanding of co-location only relates to the use of simple input-output linkages between businesses to describe the cost savings.

4.2.4.2 Networks

Networks are primarily described as linkages between local businesses that produce outputs used by other local businesses for market and also utilise inputs from corresponding local businesses. These input/output relationships usually consist of a formal supply chain linkage and represent a vertical integration. In this study a distinction between networks and clusters was used with the main difference being that networks can transpire between geographically distant businesses, whereas clusters have location specific characteristics and may correspond to regional, state and national programs and policies.

The distinction used in this study between networks and clusters has not been proposed by all cluster research and studies. Marceau (1997) stated that networks may be the heart of functioning clusters, while Rosenfeld (1997) and Feser (1998) believed that networks and clusters are also linked in some manner.

Feser (1998) describes networks as economic clusters that are not dependent on geographic location but consist of businesses linked through a supply chain relationship.

Porter (1998) links networks and clusters together stating that “a cluster is a form of a network that occurs within a geographic location, in which the proximity of firms and institutions ensures certain forms of commonality and increases the frequent and impact of interaction.” (p. 226). Enright (1998) excluded networks in his research to classify clusters. The distinctions between clusters and networks found in literature are summarised in Table 4.1, with one of the interesting differences being that in clusters competition acts alongside cooperation while networks only involve cooperation.

Table 4.1: Differences between clusters and networks (Rosenfeld, 1997)

Networks	Clusters
Networks allow firms access to specialised services at lower cost	Clusters attract needed specialised services to a region
Networks have restricted membership	Clusters have open membership
Networks are based on contractual agreements	Clusters are based on social values that foster trust and encourage reciprocity
Networks make it easier for firms to engage in complex business	Clusters generate demand for more firms with similar and related capabilities
Networks are based on cooperation	Clusters take both cooperation and competition
Networks have common business goals	Clusters have collective visions

4.2.4.3 Industrial Districts

The term industrial district was first used by Marshall (1920) to describe the agglomeration of businesses. These businesses achieved external economies of scales through co-location. These economies are external to the business but internal to the region for groups of small to medium sized firms. These economies provide a competitive alternative to the internal economies of scale achieved by large firms (Asheim, 1994).

The concept of industrial districts underwent a resurgence in interest in the 1970's due to the rapid growth of specialised districts in Italy (Sabel, 1982; Brusco, 1982; Becattini, 1990). Becattini (1990) defined the industrial district as "a socio-territorial entity which is characterised by the active presence of both a community of people and a population of firms in one naturally and historically bounded area." This interest in industrial districts by researchers lead Piore and Sable (1984) to develop a new model of manufacturing based around flexibility and specialisation.

Lazonick (2006) notes, that there are two important differences between the Italian industrial districts and the British industrial districts that were first reported by Marshall. These differences are:

- there are a collective of institutions in Italy that support the innovative activities of small businesses.
- in the Italian industrial districts, leading businesses would emerge, capturing the resources of the district and, through their own growth, enhance the innovative capabilities of the district.

Firms in industrial districts can be linked in three different ways: horizontally, where the same stage in a process is involved; laterally, when different stages of a process are involved, and diagonally, when service processes are involved (Bellandi, 1989). These links enable the formation of an innovative capacity and competitive advantage at a regional level. Garofoli (1991) summarised the characteristics of industrial districts as:

- extensive division of labour between businesses in the local production system.
- strong product specialisation at the business level, which stimulates the accumulation of knowledge and new technologies.
- effective networks between businesses which allow for fast effective transfer of information and knowledge.

- highly competent work force due to formal training and transfer of tacit knowledge.

The concept of industrial districts has been summarised accordingly by Brusco (1986), who stated that “what is relevant are no longer the characteristics of one single firm, but the characteristics of the industrial district of which the small firm is a part.” The success of industrial districts is due to the economic, social and institutional aspects of the district.

4.2.4.4 Creative Milieu

The concept of creative or innovative milieu was introduced by Groupement de Recherche Européene sue les Milieux Innovateurs (GREMI) who criticised the idea of industrial districts as representing a static perspective (Camagni, 1991). Innovative milieu are relationships occurring within a geographic space that encompass a production system, different social and economic actors and a specific and unique cultures and processes that generate a dynamic innovation environment, knowledge base and collective learning platform(Camagni, 1991). The processes that generate this knowledge base are considered to be essential to maintain local economic development and the viability of a successful regional innovation system (Longhi, 1999). Camagni (1991) reports that two co-operation processes exist within the milieu:

- a set of informal relationships between customers and suppliers and a set of tacit transfers of knowledge
- a set of formalised co-operation agreements between firms and public institutions in the area of technological development, infrastructure and service provision

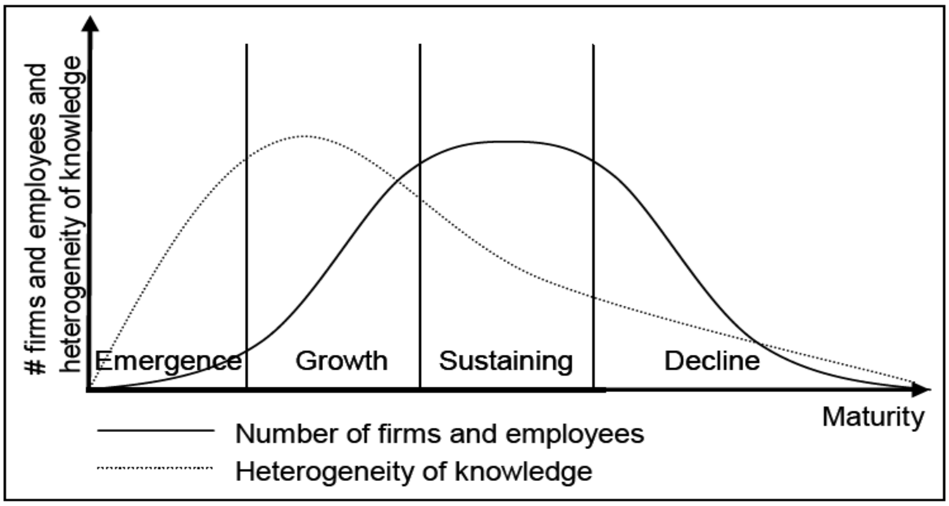
The above sections highlight the different types and nature of co-located businesses, where the actual type definition depends on the nature of the relationships or processes that are being investigated. The significance and importance of non-economic factors such as social capital (trust) and institutions for the economic growth and performance of regions and nations are also illustrated.

4.2.5 Cluster Life Cycles

Like products and industry, clusters also have a life cycle (Rosenfeld, 1997). Klepper (1997) highlighted three distinguishable industry life cycle stages: embryonic, growing and mature. In the embryonic stage there are few businesses and employees, numbers increase during the growing stage but decline once again in the mature stage. The cluster life cycle is similar to the industry life cycle where stages are described in a comparable manner to the industry lifecycle (Enright, 2003), which is similar to the evolution model of the Italian industrial districts which has three main stages of start up, development and maturity (Unioncamere, 1995).

Menzel and Fornahl (2007) have added a fourth stage, the sustaining stage, which allows for a period where a cluster can sustain itself on a high economic level. They describe the cluster lifecycle through both quantitative and qualitative dimensions. The quantitative dimension is similar to the cluster life cycle description above, where cluster development is given in terms of the number of businesses and employees. In contrast, the qualitative dimension describes the inherent cluster business competencies and knowledge during the different stages. This qualitative dimension is referred to as the cluster inherent heterogeneity of knowledge. These two dimensions and their relationship are shown in Figure 4.1.

Figure 4.1: Cluster Life Cycle – quantitative and qualitative elements (Menzel and Fornahl, 2007)



Menzel and Fornahl (2007) argue that the heterogeneity of knowledge and competencies available in the cluster are fundamental to a clusters development; and the cluster will decline if heterogeneity is not sustained, while if heterogeneity increases, the cluster moves back into the growth stage. They also note that quantitative information alone doesn't provide any indication of the condition of the cluster.

Clusters develop by extended progression through these stages and their development is always unique, specific and related to the availability of regional resources such as knowledge, labour resources, technologies and materials. Identifying a cluster's life cycle stage requires measurement of the cluster's dynamics and levels of knowledge. This measurement is complicated due to the inherent nature of the cluster dynamics. Brown (1999) notes that the position of clusters in their life cycle can, be determined by the degree of dynamism and networking that is present within the cluster.

An understanding that clusters have life cycles similar to product and industry lifecycles has caused policymakers to investigate the implications of certain cluster developments and situations. Clusters going through the same industry lifecycle can be in a different cluster life cycle stage. Saxenian (1994) revealed this in her comparison of the growing computer industry in Silicon Valley to the declining computer industry in Route 128 when the computer industry itself was going through a growth stage. Another case where cluster lifecycles are important is when regional economic diversity is reduced due to the specialised nature of the cluster. This reduced economic diversity can be dangerous when the cluster industry goes through a period of economic downturn, and it can cause negative regional growth due to the dependency of the regional economy is so dependent on cluster specialisation.

4.2.6 Cluster Types

Clusters are all highly individual even if it is possible to determine common characteristics between clusters. Individual cluster characteristics can result from different: location and geographic scope, business characteristics, scope of knowledge producing institutions and inter business relationships.

Distinct differences between clusters, allows for different types of clusters to be identified and these types can be determined from the different features of the main dimensions of the cluster. Such dimensions include:

- structure – firm size and headquarter location, presence of institutions and universities.
- relationship – goal of relationships, formal or informal links, coordination mechanism of links.
- production – manufacturing specialisation such as high-tech or low-tech, and number of different and complementary sectors.
- evolution – stage of cluster evolution process.

Carbonara and Mitra (2001) categorised three main types of geographical clusters based on cluster organisational structure:

- *Type 1* – is located in a productive environment of trusting small businesses where knowledge is disseminated through the accumulation of tacit knowledge and professional skills. A dense network of relationships and trust exists between businesses and individuals. This type of cluster is very representative of industrial districts.
- *Type 2* – is a large number of SMEs specialising in a specific industry type. The businesses develop complementary competencies and have a dense and strong network of relationships where they co-operate as well as compete. Knowledge is accumulated through specialised learning and this type is similar in both respects to industrial districts and innovative milieu.
- *Type 3* – is characterised by the presence of one or more cluster actors. These actors may be leading businesses or a consortium of businesses, institutions or trade associations. Knowledge and innovation is influenced by these cluster actors. This type is similar to the larger more mature clusters such as Silicon Valley and Cambridge.

Markusen (1996) took a different approach in classifying cluster types by describing them based on the nature of the clustered businesses and the location of their relationships. She determined that four distinct industrial spatial types of clusters were:

- *Marshallian* – comprised of small to medium sized, locally owned businesses. Businesses network to solve problems and government policies are developed to improve cluster competitiveness.
- *Hub and Spoke* – are dominated by one or several large businesses surrounded by smaller suppliers. Cooperation exists between large and small firms but not among smaller competing firms.
- *Satellite* – are industry clusters dominated by branch plants of externally headquartered businesses. Cooperation exists with external businesses and there is minimal cluster business networking and trade.
- *State-anchored* – are clusters where the business structure is dominated by a government owned or public entity such as a military base, government offices or a university. Service and supplier businesses develop around these facilities.

The many different characteristics of these clusters or industrial districts are detailed in Table 4.2.

Table 4.2: Characteristics of different types of clusters

Cluster Type	Member Businesses	Structure	Network Type	Business Goals	Returns	Employment
Marshallian	Small to Medium, locally owned	Informal, vertical, agglomerate	Trust/ Transaction	Individual/ collective	Cost	Dependendent on economies of the cluster
Hub and Spoke	One or more large with smaller service	Formal, vertical, relational	Trust	Collective	Cost/ knowledge	Dependent on prospects of large businesses
Satellite	Medium and large branch plants	Formal, horizontal, relational	Transaction	Individual	Cost	Dependent on retaining and branch plants
State Anchored	Large public and related service	Formal, vertical, agglomerate	Transaction	Individual	Cost	Dependent on expansion of public facility

Adapted from Markusen (1996)

These cluster types best represent the way high technology industries would agglomerate. Markusen (1996) states that "a real-world district may be an amalgam of one or more types, and over time districts may mutate from one type to another." This mutation of types was demonstrated by Longhi (1999) who described the transformation of the Sophia Antipolis satellite district into a hub and spoke operating cluster. The literature reveals that there are multiple ways of describing clusters, which is dependent on what aspect of the cluster is being investigated.

There are a wide variety of clusters around the world. The regions these clusters are located become synonymous with their industry type. Some of these high performing clusters and their industry types are listed in Table 4.3. Some regions are still known for their cluster, even if that industry is currently in decline such as the automobile cluster in Detroit.

Table 4.3: Examples of international clusters

Region	Cluster	Description
Silicon Valley	Computers/Electronics	Home to nearly 7000 high technology companies
Biella, Italy	Textile	Major destination for wools and home to 1300 textile mills and 200 textile machinery manufacturers
Dalton, Georgia	Carpet	Has nearly 174 carpet mills that produce nearly half the worlds carpet
Wichita, Kansas	Aeronautical	Produces over half the worlds small aeroplanes
Sheffield, Yorkshire	Metal	Stand out location for the production of cutlery
Cambridge, England	High technology	Home to nearly 1200 high technology companies

Adapted from Rosenfeld (1997) and Ffowcs-Williams (2001)

Ffowcs –Williams (2000, 2001) notes that across these high performing and vibrant clusters, four key elements are present:

- *Core Businesses* – which are the key and lead participants in the cluster. Proximity allows for the development of linkages and trust between the businesses. There exists a culture of both co-operation and competition.
- *Support Businesses* – which supply specialised equipment and services to the core businesses.

- *Soft Support Infrastructure* – which is a vital element in knowledge and technology clusters that involves linkages with universities, research institutions and industry associations.
- *Hard Support Infrastructure* – which includes physical infrastructure such as roads, telecommunications and buildings.

4.2.7 Australian Clusters and Clustering

Even though clusters and clustering have strong economic benefits at a regional or national level, there has been minimal research conducted on this area in Australia. Enright and Roberts (2001) have published the most definitive work in this area in which looks at specific clusters and processes. Morkel (1993) identified that local attributes must be developed to support emerging and developing clusters, knowing that clusters are important for Australia's industrial productivity. Clusters and knowledge networks have also been identified as important drivers for Australia's knowledge economy (Marceau, Sicklen & Manley, 1997).

Johnston (2004) developed a substantial list of what clusters in Australia. He classified these clusters as strong, moderate, potential or maybe clusters. The criteria for this classification include both interaction strength and output strength. Of the 62 clusters, only 7 clusters were classified as strong. This is due to three problems identified by Brown (2000) in his investigation of 70 regional cluster initiatives:

- insufficient critical mass
- lack of focus and distinctiveness
- political and administrative difficulties

Marceau (1999) had previously identified that clusters were weak in Australia because of the failure of business and government policies to increase and develop networks of collaboration, knowledge and technology sharing between businesses. Lowe and Miller (2001) argue that there has been no literature evidence linking economic development to clustering or specific cluster methods or processes.

This may be due to fact that no two clusters are identical and so it is difficult to compare one cluster process with another, as location is a key element in cluster dynamics, processes and policies.

The recognition of Australia's geography and lack of global economies of scale, led Marceau (1999) to develop the concept of virtual clusters. These virtual clusters are networks of local businesses and industries that have linkages with businesses in the same industry sector, but are located in other regions. Many small clusters might be classified as wannabe clusters due to their lack of critical mass or lack of falling into a defined industry type (Rosenfeld, 1997). It is difficult to recognise these clusters using the top down approach of analysing various standard data sources, and so to identify and understand these clusters an approach recognising business relationships and linkages needs to be implemented.

4.3 Cluster Methodologies, Models and Policies

Methodologies for considering cluster processes as a critical part of cluster identification have been mainly developed by cluster practitioners. These methodologies are unique and diverse and are directed by specific objectives. Verbeek (1999) reported that identification methodologies for national and regional clusters are dependent on statistical analysis of industry data from official census and government surveys. This is ideal for larger clusters and easily identifiable industries, but is limited for micro clusters and industry sectors that fall across different industry classifications.

Combining qualitative data with quantitative data provides a useful and proficient framework for development of methodologies to identify and analyse different types of clusters (Held, 1996). This allows for the complex characteristics of the cluster to be identified and in turn this identification will allow for the cluster processes and strengths to be enhanced even if the cluster doesn't have major economic significance.

Different methodological approaches have identified that clusters evolve and have a lifecycle and so any methodology needs to consider these development factors. One of these approaches was the South Australian Business Vision 2010 cluster program which was developed to utilise collective instincts and regional attributes to drive economic and social outcomes (Blandy, 2001).

Rosenfeld (1995) and Austrian (2000) described methodologies as bottom up approaches in that the cluster and cluster processes are developed from an understanding of the existing specific regional and economic attributes. Building upon these attributes allows for cluster and regional growth. The bottom up approach measures and describes:

- industry type, concentration and linkages
- business relationships within the region
- nature of regional economics

Ffowcs-Williams (2000) and Enright (2000) deviate from using clustering identification and processes as a methodology, by basing their methodological approach on specific cluster strategies. They identified three different cluster strategies being:

- organic – directed to the expansion of the current economic base.
- transplant – designed to attract foreign firms.
- hybrid – essentially a combination of organic and transplant.

These strategies still require identification and analysis of factors to understand the dimensions and characteristics of the cluster.

4.3.1 Cluster Models

There are a wide variety of cluster models, ranging from simple to more complex, including:

- Agglomeration (Marshall, 1920; Feser & Bergman, 2000; Chapman, 2000)
- Network (Rosenfeld, 1997; Ffowcs-Williams, 2000; Enright, 2000)

- Innovation (Verbeek, 1999)
- Policy (Jacobs & de Man, 1996; Boekholt & Thuriaux, 1999)
- Industry Competitive Advantage (Porter, 1990)
- Learning and Knowledge (Piore & Sable, 1984; Swan *et al.*, 1998; Keeble *et al.*,1999; Lawson & Lorenz, 1999)

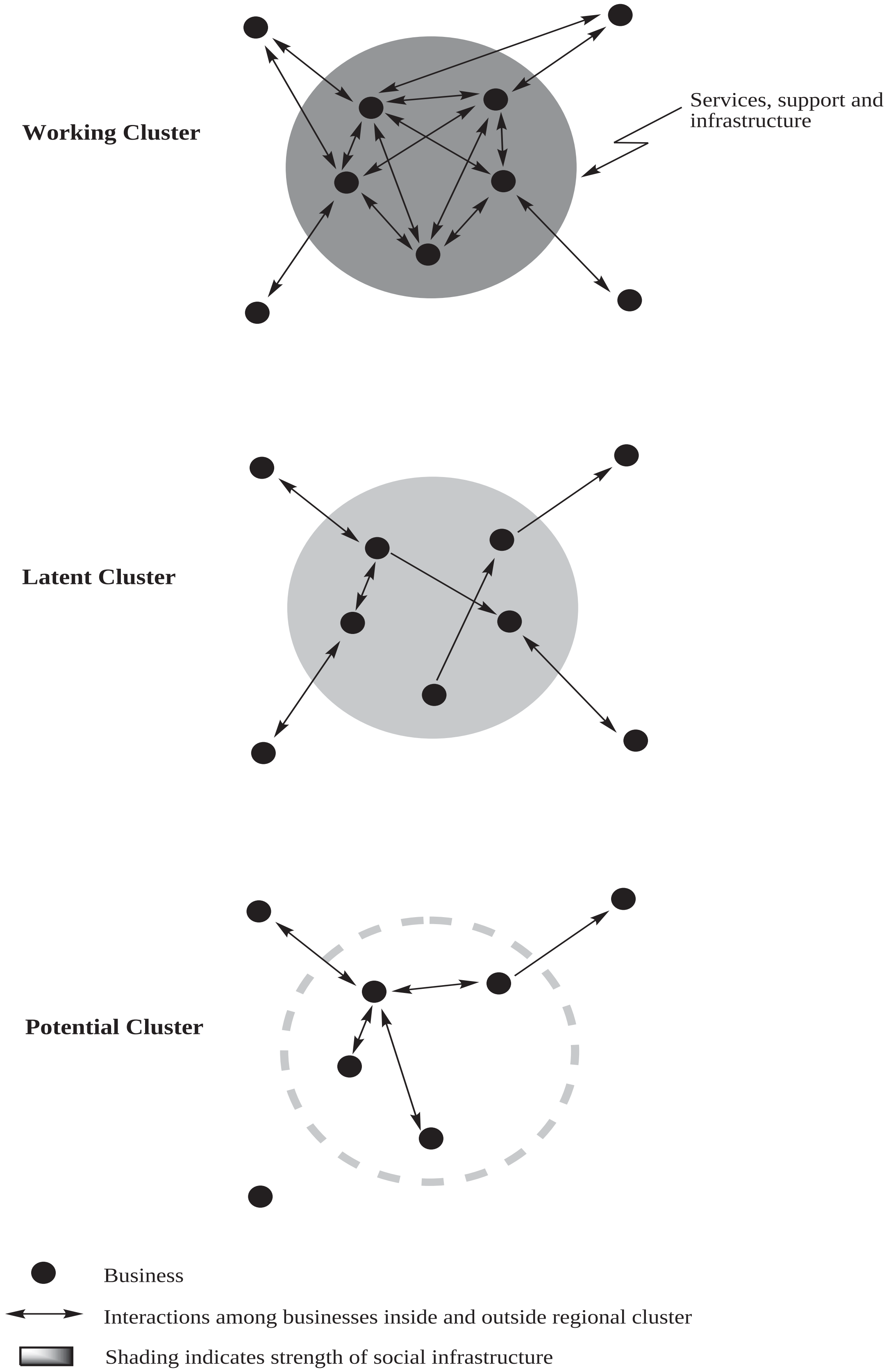
In his famous work, Porter (1990) uses clusters as one of the key concepts in his Diamond Model of competitive advantage. The model has been extensively used to determine how businesses are related and how support industries have an effect on competitiveness.

Rosenfeld (1997) suggests that there are three types of clusters that are distinguishable through their strength of social interaction and the nature and intensity of links between businesses within and outside the region:

- *Working Clusters* – over achieving clusters which have strong interactions between businesses, realise their full potential and produce more than the sum of their parts.
- *Latent Clusters* – under achieving clusters, where businesses don't view themselves as a cluster so the potential is not realised even though the scale and concentration exist.
- *Potential Clusters* – these clusters have some of the key elements but are missing the critical mass and inputs.

Another type of cluster that Rosenfeld (1997) notes is the 'wannabe' cluster which, because of its lack of critical mass, comparative concentrations or political power, often goes unnoticed. Small or rural clusters and industry types that don't conform to a standard classification often fit into this category. The three main cluster types are best represented in Figure 4.2, which highlights the business links and the extent of social infrastructure.

Figure 4.2: Types of Clusters determined through their social interaction (Rosenfeld, 1997)



Brown (2001) notes there are three identified underpinning principles of clustering that are present in different degrees no matter the size, structure, industry sector or location:

- commonality – businesses are operating in common or related industries with a shared market or activity.
- concentration – there is a grouping of businesses than do and can interact.
- connectivity – interconnected organisations and businesses with a range of unique types of relationships.

4.3.2 Cluster Policies

A number of organisations operating at regional and national level are adopting cluster policies to increase economic growth and international competitiveness (Cumbers and Mackinnon, 2004). Many of the cluster policies developed and implemented have been influenced by Porter's (1990) work. His approach in recognising that clusters are influenced by chance events, location and business competitiveness requires governments to identify, map and describe clusters, but this identification is highly dependent on available information. Cluster mapping usually involves using national data such as number of businesses, number of employees, input/output on a certain region or industry type. This top-down approach has been used to describe clusters, such as the Californian wine industry (1999) and Silicon Valley.

Cluster policies are still in early stages in most countries and there has been only limited work done to compare these policies (Oxford Research, 2008). Roelandt and den Hertog (1999) identified a number of policies that have been developed according to specific and local conditions. This implies that these policies can be altered to meet the needs of the regional companies and contextual conditions. Clusters have developed without the implementation of policies intended to create clusters and so most policies are designed to foster the development of clusters and increase their regional and national economic benefits.

Oxford Research (2008) defined cluster policies as policies that could fit into one of the three following categories:

- cluster development policies – which strengthen a particular cluster.
- cluster leveraging policies – which increase efficiency of the cluster.
- cluster facilitating policies – which remove competition obstacles to increase the emergence of clusters.

Anderson et al, (2004) note other more specific policy types, such as international linkages, training policies, demand policies, market policies and broker policies. Den Hertog (2003) states that "cluster policies are dependent on the stage in the cluster lifecycle and should balance creating and sustaining innovative clusters." It is recognised that no single policy can be employed in all cases relating to clusters. Rosenfeld (2002) notes that cluster policies need to be flexible and den Hertog (2003) states that mapping of clusters to identify barriers, allows cluster policies to be created, altered or adapted.

As every region's economic structure is unique, governments and policy makers must heed this uniqueness when developing regional innovation and cluster policies (Hopsers and Beugelsdijk, 2002). This means that policies are firmly rooted in regional socio-economic and institutional environments (Diez, 2001). There are four distinct objectives that drive cluster initiatives and policy making (Boekholt and Thuriaux, 1999):

- improving the national advantage of certain sectors
- increasing and intensifying industry research collaboration
- increasing the attractiveness, competitiveness and economic performance of a region
- increasing the economic development and competitiveness of SME's

Rosenfeld (2001) reports that dynamic regions are most likely to produce clusters and networks without the need for government incentives and policies, while Breschi and Malerba (2001) argue that cluster policies should be concentrated on new business formation and the investment in education and infrastructure support.

It is these objectives and the ultimate goal of gains in production, productivity, innovation and wealth resulting from successful clusters which are causing increasing numbers of nations to develop cluster policies for economic growth.

4.4 Cluster Links

To understand the linkages occurring within clusters it is necessary to determine the character and geographic scope of those linkages. Differentiation between types of linkages is not well documented in the literature, and there has been limited research to assist in determining the different types of inter-business linkages. Furthermore the research that has been undertaken is predominantly qualitative in nature.

Maillat (1991) differentiated cluster linkages based on whether they were trivial or simple links, as opposed to determining or complex links, in the innovation process. He deemed that collaborative links with other businesses and research and higher education institutions were complex in nature, whereas contacts and links with customers, service and equipment suppliers were trivial in nature. These different links are summarised below in Table 4.4.

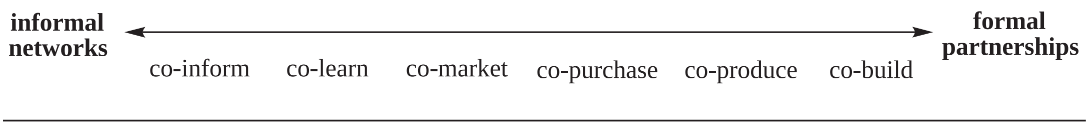
Table 4.4: Trivial and Determining Links

Trivial/Simple Links	Determining/Complex Links
Labour	Collaboration with other businesses
Equipment suppliers	Collaboration with research institutions
Customers	Collaboration with higher education institutions
Service providers	Scientific and technical information
Finance agencies	Part of a network
	Consultants

Adapted from Miliat (1991)

Waits and Howard (1996) describe different cooperative activities that agglomerated or clustered businesses undertake. In their study of Arizona industries, Waits and Howard elaborates on Miliat's description by excluding simple linkages to concentrate on developing descriptions of complex linkages ranging from informal networks to formal partnerships (Figure 4.3).

Figure 4.3: Continuum of Industry Collaboration (Waits and Howard, 2006)



As the linkages move from informal networks to formal partnerships they become more complex and usually involve more participants. A description of each of these activities is provided in Table 4.5.

Table 4.5: Description of activities of industry collaboration

Activity	Description
Co-inform	Initiatives designed to improve communications between your business and other businesses. These initiatives can be industry newsletters, databases, industry surveys, business directories.
Co-learning	Development and participation in educational programs, conferences and seminars to learn how and where to acquire resources, services and better business practices.
Co-market	Participation in trade missions, trade shows, industry brochures and advertising campaigns both nationally and internationally to promote the products of the business and other co-located businesses.
Co-purchase	Businesses purchasing equipment jointly, undertaking collective training programs and joint outsourcing plans that the individual businesses otherwise could not afford.
Co-produce	Jointly manufacturing a product or undertaking R&D collaboration.
Co-build	Clustered businesses build better and stronger links with educational institutions, government and lobby for funds on a collective basis.

Adapted from Waits and Howard (1996)

Although these links can occur at a local, regional, national or international level, for links to be considered useful for regional development they need to occur at a local or regional level.

4.5 Competitive Advantage

A variety of reasons exist for businesses to cluster in one specific location, but the main underlying reason is to obtain a competitive advantage over competitors. A characteristic of clusters is the network of relationships that exist between businesses, which allows businesses to take advantage of complementary activities such as exploiting markets and pooling knowledge and resources. Businesses involved in these relationships report that their competitiveness, innovation and profitability are enhanced.

Another advantage of clusters is the propensity for higher job growth and business formation. Baptista and Swan (1999) determined in a comparative study on US and UK computer industry clusters that strong clusters are more likely to attract new businesses to the cluster region, and that the businesses located within these strong clusters tend to grow more quickly. An example of this is the Cambridge high-technology cluster which has grown from 80 small to medium high-tech businesses in 1980, to nearly 1200 businesses in 1999. This attraction and growth leads to regional economic growth and further businesses being attracted to the region. Porter (1998), states that this type of competitive advantage resides outside the business and instead resides in the actual location of the business. Even though the business may have an advantage being located in a particular region, it can not rely on this to overcome its own business deficiencies such as poor management and practices (Martin and Sunley, 2003).

Martin and Sunley (2003) report that there are also potential disadvantages associated with clusters. These potential disadvantages are shown in Table 4.6 alongside the potential advantages.

Table 4.6: Cluster benefits and costs (Martin and Sunley, 2003)

Claimed Advantages	Potential Disadvantages
Higher innovation	Technological isomorphism
Higher growth	Labour cost inflation
Higher productivity	Inflation of land and housing costs
Increased profitability	Widening of income disparities
Increased competitiveness	Over-specialization
Higher new firm formation	Institutional and industrial lock-in
High job growth	Local congestion and environmental pressure

The major disadvantage of clusters is if the cluster locks in established industries and practices. The region will prosper and grow while these industries are growing, but if they start to decline and the region doesn't have a diversity of industries, then the region begins to falter. This has been the case in regions that have had major manufacturing plants in the automobile industry (in Detroit) and defence contracts (in San Diego). Over specialisation can lead to internal decline of the cluster and businesses within the cluster, as businesses are unable to adapt to major shifts in products and technologies as they are locked in to a specific technology or product.

4.6 Chapter Summary

This chapter has discussed differing concepts of clusters, beginning with their progression from earlier economic theories such as agglomeration and co-location. Differing definitions of clusters have been detailed and a range of clusters have been described. This has revealed that for the concept of clusters to be used as tool to analyse the phenomenon under investigation, the definition, models and methodologies used must be broad and flexible.

The chapter highlighted that clusters and cluster processes can be utilised to investigate and understand how businesses compete, innovate and interact with other businesses and institutions to gain a competitive advantage and have economic growth. Different cluster definitions have been offered, but a broad definition is used in that a cluster is a group of businesses in a geographic space that face common opportunities and threats and gain advantages through co-location. The chapter discussed other types of geographic concentrations of businesses such as industrial districts and creative milieu and highlights that clusters have a lifecycle similar to products and technologies. These types of co-location of businesses all share common traits and verify that success of a region and industry depend the on economic, social and institutional aspects of the region.

A range of cluster models and methodologies have been discussed that are relevant to small clusters, as well as different types of cluster linkages. The chapter described that small clusters or industry types that don't fit a certain classification may be viewed differently and need different identification processes than larger national clusters. This leads this study to utilise a variety of clustering models and methodologies to define and understand the characteristics and relationships of co-located businesses.

The next chapter is the framework for this study and is developed from the understanding and interpretation of the concepts in the previous two chapters on university-industry links and clusters.

Chapter Five

Framework

5.1 Introduction

This study involves two different but inter-related areas; it is aimed at investigating and answering questions relating to industry links within the advanced manufacturing sector, and it seeks to explore the nature and extent of interactions between university researchers (academics) and the industrial and government sectors.

Using clusters as the basis of the study, a framework has been developed to classify cluster types and to recognise the unique characteristics of clusters for different regions and industries. For university-industry links, different framework aspects will be used to develop a structure that comprehends the different types of links, the nature of industry partners and the benefits of industry collaborations for different universities. The framework will also reflect the social structure of these links and methods for increasing the extent of these links. The framework in this study is used to analyse the nature of links between different advanced manufacturing businesses and the nature and extent of university- industry relationships.

The chapter will describe what a university-industry relationship is, by the type and of collaboration and the nature of industry partners involved in these collaborations. It will also propose a definition of a cluster in terms of relationships between different business and university partners. The framework from these aspects forms the basis for data collection and analysis and, in turn, university-industry classification and cluster classification. The chapter will initially discuss the rationale for using a framework (Section 5.2) and different types of university-industry relationships. Section 5.3 describes the industry partner classifications used in this study and the benefits of university-industry links. Section 5.4 describes the different dimensions and elements within clusters and the cluster and relationship classifications utilised in this study. The final two sections summarise the framework used for this study (Section 5.5 and 5.6) and where this framework is positioned within the research areas of university-industry links and clusters.

5.2 Framework Rationale

To analyse and solve a problem, research often uses a number of different organising methods such as theories, models and frameworks. A framework is essentially a method of connecting all types of inquires such as research purpose, problem definition, previous literature, methodology, data collection and analysis. Ostrom and Ostrom (2004) describe it as a means of organising both diagnostic and prescriptive inquiry. Frameworks are used to guide data collection and interpretation and so in this research a framework approach is utilised.

The choice of framework is often directed by the nature of the problem being investigated (Shields and Tajalli, 2006), but Dewey (1938) highlights the fact that conceptual tools have to be altered to meet the demands of changing problems. This means there are two types of possible frameworks that can be utilised; existing frameworks that can be readily used and frameworks that must be created specifically for the problem. Shields and Tajalli (2006) classify frameworks into five distinct categories:

- Working hypotheses
- Categories
- Practical ideal type
- Models of operation research
- Formal hypotheses

These frameworks are linked to a specific research purpose and so once the research purpose is identified the corresponding framework is used. Research and statistical techniques are easily linked to the framework, and the association between research purpose, framework and research and statistical techniques is shown in Table 5.1.

Table 5.1: Conceptual Framework Classification (Shields and Tajalli, 2006)

Research Purpose	Research Question	Conceptual Framework	Research Technique/ Methodolgy	Statistical Techniques
Exploration	Anything goes: what, when, where, why, who, how, or any combination ofthe above	Working hypotheses	Usually qualitative techniques: field research, structure interviews, focus groups, document/archival record analysis	Qualitative evidence may not be statistical Any type of statistical analysis possible
Description	What	Descriptive categories	Survey and content analysis	Simple descriptive statistics: Mean, mode, median, frequency, percentages, t-statistics
Gauging	How close is process/policy to an ideal or standard? How can x be improved?	Practical ideal type	Case study, survey, content analysis, document analysis, structured interviews	Simple descriptive statistics: Mean, mode, median, frequency, percentages, t-statistics
Decision making	What is the best decision? Which approach?	Models of operations research	Cost benefit analysis, cost effectiveness, linear programming, decision tree	Quantitative techniques of operations research
Explanation	Why	Formal hypothesis: if x then y	Usually quantitative, experimental and quasi experimental design, survey, existing data analysis	t-statistics, correlation, chi-square analysis of variance, simple and multiple regression

Frameworks allow for theories to emerge that enable aspects of the framework to be linked to specific questions or assumptions relating to the phenomenon. Ostrom and Ostrom (2004) note this allows for explanation of processes, prediction of outcomes and identification of the important elements of the phenomenon.

Dewey (1938) notes that conceptual frameworks can be considered as maps that help navigate through reality. These maps can be used as a tool to identify the different components and the nature of these components within a particular phenomenon. In this case, the phenomena are university-industry collaborations and clusters. In research on university-industry links, maps have not been utilised to investigate the nature and location of industry partners, but maps are extensively used in cluster research to represent the different dimensions and relationships that exist within the cluster (Austrian, 2000). These maps provide a level of data representing key cluster elements for specific regions and industries (Porter, 1990).

For university-industry links, the research literature concentrates on the type of different linkages and the advantages and disadvantages of these linkages from both university and industry view points. To the researcher's knowledge, there has been limited research has been conducted to investigate the nature and location of industry partners involved in collaboration with universities. Understanding the nature and extent of these partners requires various levels of analysis, so a framework is required in this part of the study.

Research on clusters tends to focus on defined industries and regions. A range of criteria is required to classify clusters that are not defined by a specific industry classification. Rosenfeld (2002) notes that a framework allows a broader set of dimensions and commonalities to be identified, enabling the true nature of the cluster to be captured. There are a variety of factors that cause cluster development such as natural resources, infrastructure, knowledge, history, critical businesses, people or interactions and chance. With these factors, a cluster is an effective way to explore and understand business links and location advantages for the advanced manufacturing sector. As for the university-industry links section of the study, a framework approach is required.

5.3 Framework – University-Industry Links

Most universities around the world collaborate with industry in some form or another. Universities collaborate with industry for a variety of reasons, as discussed in Chapter Three. Collaboration with universities has become an increasingly important strategy for businesses to obtain complementary and emerging knowledge and technologies.

Valentín (2000) asserts that there are four reasons why university-industry links should be investigated and analysed:

- university-industry links represent a critical part of national R&D.
- current university-industry relationships could give rise to more complex collaborations.

- forces such as increased innovation and declining government resources increase the importance of these links.
- university-industry research centres are growing in importance.

Research into university-industry links has traditionally focused on the extent of intellectual property, co-authoring, patents and technology transfer. While this research allows for analysis of quantitative data, it is doesn't account for the social relationships and motivations underpinning the links (Perkmann & Walsh, 2007). Thune (2007) also asserts that macro-level data underestimates the degree of collaborations as they miss the informal and non-institutionalised character of many university-industry links. D'Este and Patel (2007) note that too much attention on patenting and spin-off activities obscures other university-industry links that are important in frequency and economic impact but don't have a visible economic reward. This lack of understanding of the social aspects of university-industry links has led researchers to use surveys to collect data from either academics or industry partners or a combination of both.

Bonaccorsi and Piccaluga (1994) emphasise that with researchers have been interested in two main research issues associated for university-industry relations:

- intensity of relations – size of partners, industry sectors in which relations were developed and countries of origin of partners.
- characteristics – types of collaborations, terms of agreements and scientific fields which are studied.

As this study is investigating the nature and extent of university-industry links for South Australian universities, the framework for this investigation must allow for the determination of the type of link, benefits and ways of increasing university-industry links and the nature and location of the collaborating industry partner.

5.3.1 Nature of University-Industry Links

A comparison between the nature of university-industry links studied within the literature indicates that university-industry links have a multi-faceted nature

(Mansfield, 1995; Lee, 2000; Bonaccorsi & Piccaluga, 1994; Meyer-Krahmer & Schmoch, 1998; Cohen *et al*., 2002; D'Este & Patel, 2007). Meyer-Krahmer and Schmoch (1998) identified various mechanisms that act as means through which resources, knowledge and information are produced or exchanged between the industry and university partners. These mechanisms have also been referred to in literature as channels (Cohen *et al.* 2002, Schartinger *et al.* 2002).

Perkmann and Walsh (2007) used the generic category 'university-industry links' to cover both categories of channels and mechanisms. Their different university-industry links are shown Table 5.2 and cover ways in which university-industry research benefits both parties and the economy.

Table 5.2: University-industry links (Perkmann and Walsh, 2007)

Research Partnerships	Inter-organisational arrangements for pursing collaborative R&D
Research Services	Activities commissioned by industrial clients including contract research
Academic entrepreneurship	Academic inventors develop and commercialise their technology through a company they set-up
Human resource transfer	Different learning mechanisms such as postgraduate training in industry, training of industry employess and secondments to industry
Informal interaction	Formation of social networks and relationships
Commercialisation of property rights	Transfer of university generated intellectual property such as patents to industry via licensing agreements
Scientific publications	Use of codified scientific knowledge within industry

Schartinger *et al.* (2002) identified sixteen types of knowledge interactions grouped into four main categories:

- Joint research
- Contract research
- Mobility
- Training

Cohen *et al.* (2002) distinguished between these categories based on the relevance to industrial innovation such as patents, contract research and CRCs.

Frameworks for these links have been used to investigate the levels at which links are maintained (Howells *et al.* 1998), where the links stand between industry pull and university push (Poyago-Theotoky *et al.* 2002), and benefits and obstacles to the links (Valentín, 2000). Bonaccorsi and Piccaluga (1994) used inter-organisational theory in organisation theory to identify different organisational dimensions of university-industry relationships. They identified six groups of university-industry links that are defined according to the level of organisation. The six groups are shown in Table 5.3 with an increasing level of organisational involvement.

Table 5.3: University-industry inter-organisational relations (Bonaccorsi and Piccaluga, 1994)

University-Industry Relationship	Characteristics	Examples
Personal Informal	Exchange between firm and an individual academic No formal agreement involving the university	- Research publications - Academic spin-offs - Informal exchange workshops
Personal Formal	Exchange between the firm and an individual academic Formalised agreements between the firm and the university	- Postgraduate linkages - Exchange of personnel - Student interns and placements
Third Parties	Relations that are developed through intermediary associations Third parties can be run by the university or completely external to it	- Liaison offices - Industrial associations - Applied research institutes
Formal Targeted Agreements	Formalisation of agreements Definition of specific objectives	- Contract research - Joint research programmes
Formal Non-targeted Agreements	Formalisation of agreements Relations are broader and have long-term strategic objectives	- Industry sponsored R&D in university departments - Research grants and donations
Creation of Focused Structures	Research carried out together in permanent structures	- Cooperative research centres - Research and science parks - University-industry research consortia

Bonaccorsi and Piccaluga (1994) note that the different types of relations can be analysed based on the following aspects; length of agreement or project, organisational resource involvement from the university, and the degree of formalisation.

Perkmann and Walsh (2007) distinguished between two main types of university-industry links based on research partnerships and research services and are distinguished based on the degree of finalisation. Weingart (1997) refers to the concept of finalisation as the degree to which research follows a specific purpose as compared to increasing new knowledge. This is seen in Figure 5.1, where the type of industry funded research ranges from blue sky research with a low degree of finalisation, to research with a high degree of finalisation, such as contracted research with specific objectives and outcomes.

Figure 5.1: Finalisation continuum of industry-funded research (Perkmann and Walsh, 2007)

Research Partnerships		**Research Sevices**
Collaborative (or sponsored) research		Contract research
University-industry research centres		Consulting
low ←	**finalisation**	→ **high**

This distinction allowed Perkmann and Walsh (2007) to state that research partnerships are "designed to generate outputs that are of high academic relevance and can be used and adapted for academic publications", while research services are "provided by academic researchers under the direction of industrial clients and tend to be less exploitable for academic publications." Schmoch (1999) notes that academics and businesses can have both types of links occurring simultaneously and that different institutions, can classify these links in different manners.

The contract research (Schartinger, 2002), formal targeted agreements (Bonaccorsi and Piccaluga, 1994) and research services categories (Perkmann and Walsh, 2007) include consulting, which Perkmann and Walsh (2008) defined "as the provision of a service by academics to external organisations on commercial terms". They state that three different types of academic consultancies exist, depending on motivation, type of knowledge exchanged or produced and the nature of the relationship (Table 5.4).

Table 5.4: Types of Academic Consulting (Perkmann & Walsh, 2008)

	Motive	Relationship	Type of knowledge
Opportunity-driven	Income	Short-term	Openly accessible, specialist expertise
Commercialisation-driven	Technology development	Project-bound	Tacit expertise
Research-driven	Research opportunities	Long-term, embedded	Strategic judgement, know-what

Even though academics undertake consulting, their basic research levels and values can still be investigated as Perkmann and Walsh (2008) note that consulting has limited impact on academic's direction of research and that academics undertake both applied and basic research.

5.3.2 Type of Industry Partners

Minimal research has been conducted to analyse and determine the nature of industry partners that are involved in university-industry links. A descriptive approach was used for this section to allow for the definition and description of industry partners. These definitions and descriptions are shown in Table 5.5. This approach allows for an industry partner to be categorised from the secondary data involving ARC linkage projects and for university respondents in the questionnaire to identify the industry partners they collaborate with. It was deemed that these categories and descriptions best covered the nature and location of all industry partners that would be involved in university-industry links.

Table 5.5: Classification of industry partners involved in university-industry links

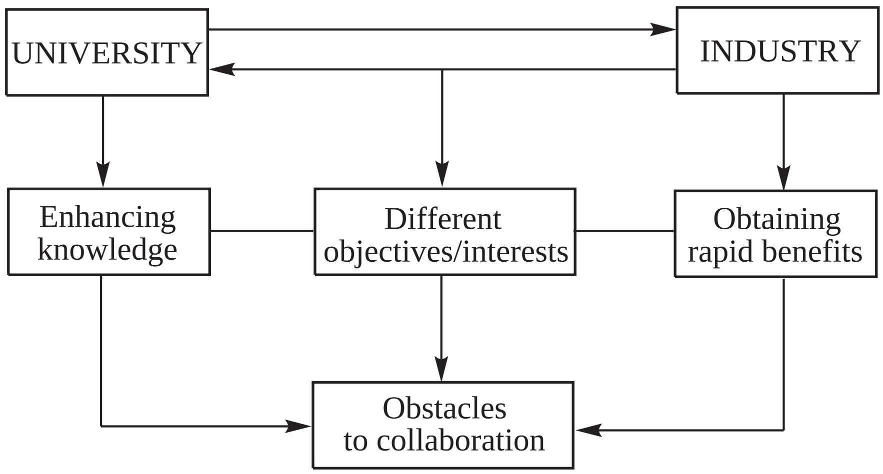
Classification	Definition
State	The participating business and university are located in the same Australian state.
Inter State	The participating business and university are located in different Australian states.
National	The participating business on the ARC linkage project is located in 4 or more Australian states or territories.
Local Government	The local government is in the same Australian state as the collaborating university
State Government	The government department, office or agency is in the same state as the collaborating university. Excludes businesses that are owned by the government but trade as a seperate entity.
Federal Government	The department, office or agency on the project is Federal Government in nature.
Inter State Government	The government department, office or agency and university are located in different Australian states.
International - Australian Operations	The business is international but has an office in one of the Australian state.
International	The business is international but has no offices in Australia.
Unknown	The business location is unknown.

The unknown category is allocated to businesses whose location can't be determined and this category will not be used in the analysis section on university-industry links analysis section. Private non-profit organisations are users of research and are involved in ARC linkage projects, so these organisations were classified within the first three categories as private business for this section but were considered a separate category for the questionnaire. This industry partner framework allows for a determination of the types of partners that universities collaborate with and whether these industry partner types differ for each university.

5.3.3 Benefits of University-Industry Links

This section of the research investigates the benefits of university-industry links from both university and industry perspectives and ways in which these links can be improved. To construct a framework for this section, different benefits for university and industry partners must be considered. Senker and Senker (1997) state that the benefits from links are different as the expectations of universities and businesses in these relationships or links are quite different. The divergence of these expectations or objectives, are best represented in Figure 5.2, which shows that universities prefer to enhance knowledge and businesses prefer to obtain rapid benefits.

Figure 5.2: Divergence of objectives in university-industry relationships (Valentín, 2000)



An understanding of these objectives allows for a determination of benefits that universities and industry are expecting to obtain from entering into university-industry collaborations. Bonaccorsi and Piccaluga (1994) formulated motivations that lead businesses to collaborate with universities and Chen (1994) analysed the benefits that businesses obtain from direct collaboration with universities. Both of these studies ignored potential benefits to universities, however Valentín (2000) developed a framework of motivations and benefits that can be obtained by both academics and businesses from university-industry links. Valentín's framework also goes a step further to highlight the motivations and benefits for government involvement in university-industry collaborations (see Table 5.6).

Table 5.6: Benefits and motivations for university-industry-government cooperation (Valentín, 2000)

Benefits	University	Industry	Government
Financial	New financial sources, obtaining public grants	Reducing costs, sharing risk, obtaining public grants	Justify big budgets for projects as hidden benefits are obtained
Technological	Access to firm's resources	Access to university's resources, R&D collaboration projects, technological advances	Exploitation of technological spill-over
Strategic	Scientific breakthoughs, access to managerial experience	Maintaining/improving competitive advantage, creating strategic alliances	Emergence of new technology based industries, strengthing regional innovation system, increasing economic development
Motivations			
Educational	Contribution to knowledge diffusion, more practical training	Access to the new knowledge and skills in the university laboratories	Enhancement of the national educational system
Political	Enhancement of reputation, responsiveness to government initiatives	Increase in the level of national competitiveness, enhancement of reputation	Integrated science, technology and industrial policy
Epistemological	Testing existing theories, citations, publications, increasing science's predictive power	Access to innovative scientists, solving scientific problems	Upgrading the skills and science base, improving national self-esteem

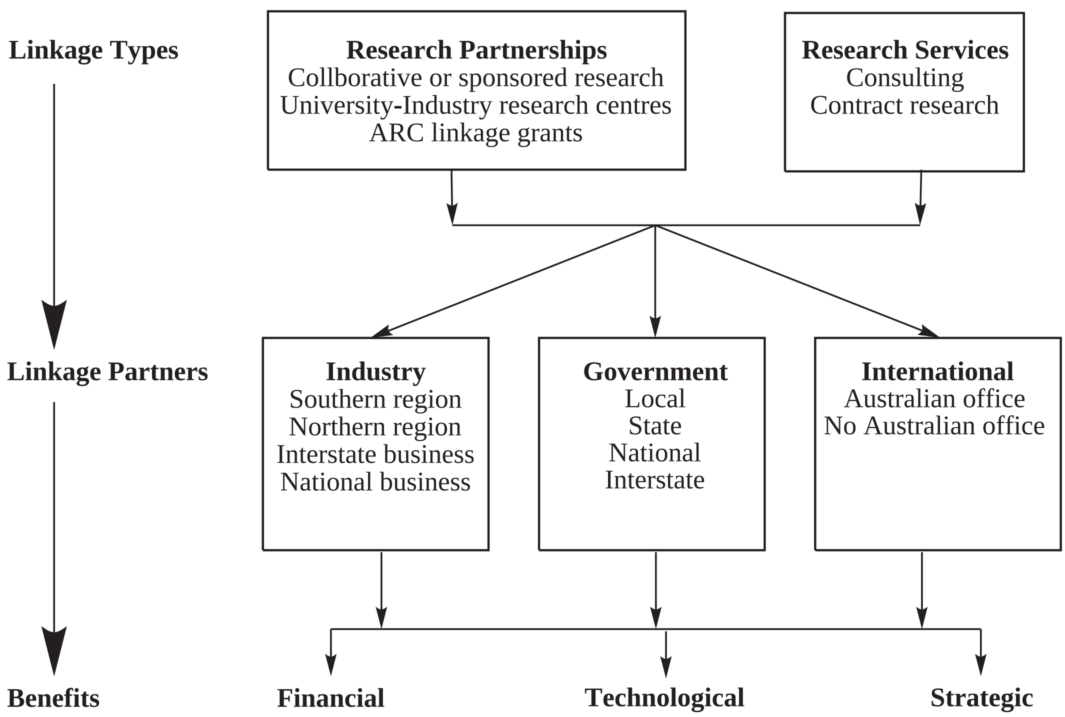
While benefits are obtainable for both collaborating parties, obstacles to these collaborations exist due to the divergence of the parties respective objectives and structures. These obstacles can affect the number and strength of university-industry links and views by academics can highlight means by which these levels can be increased.

5.3.4 Summary

The framework that has been described is intended to be used to understand and assess the key characteristics of university-industry links for different universities. To further develop this framework, the study assumes that university-industry links constitute one of those links mentioned in Table 5.2 and Table 5.3, and that all links involve an industry partner that falls into one of the categories in Table 5.5. It also assumes that both academics and industry undertake these relations to gain some benefit for them.

The framework for this section of the study comprises three components. The first component identifies and describes the types of industry links, and draws on the approaches developed by Perkmann and Walsh (2007) and Bonaccorsi and Piccaluga (1994), which allow for linkage types to be determined for the different universities. The second component classifies the types of industry partners involved in university-industry links, and was developed to allow for an understanding of the nature of industries that collaborate with different universities. This enables determination of whether the nature of the university dictates what businesses academics collaborate with. The third component identifies the benefits of university-industry links and means that the levels and efficiency of these links can be enhanced. This component utilises the framework developed by Valentín (2000), which identified benefits and motivations for universities, industries and government. A representation of the university-industry link framework is shown in Figure 5.3.

Figure 5.3: University-industry links framework



5.4 Framework – Cluster and Business relationships

Clusters exist for many different industry types and in a number of different regions in various forms. There is no 'magic' rule for developing a cluster or measuring the characteristics and nature of clusters. The use of clusters as an analytical tool to investigate business links and location assumes according to Rosenfeld (2002) that clusters are a rule and not an exception. This provides for the assumptions in the present study that advanced manufacturing clusters exist, and that they may not be defined according to literature definitions of clusters.

In this study, it is assumed that even though clusters, networks and agglomeration economics are related, they can be differentiated on the basis of the characteristics they exhibit. The major difference is that for clusters, geographic proximity is important for the development of valuable relationships, and that competition and co-operation are mutually inclusive. Clusters have collective visions, where individual businesses located within the cluster view the growth of the region as being as important as the growth of their business.

Ginsberg and Morecroft (1997) and Porter (1998) both suggest that businesses need to view themselves as part of an economic system that evolves over time and that interconnected businesses and institutions obtain more value as whole than as a sum of parts.

5.4.1 Key Elements of Clusters

Identification and analysis of the key elements, interactions and relationships allows one to capture the dynamic nature of industry types and location. This understanding permits for the development of a framework that encapsulates specific aspects of different clusters that might not be seen using normal approaches.

A review of the literature on clusters reveals that there are three common elements concerning clusters that need to be addressed to form the framework (Rosenfeld 1997; Enright, 2000). These three elements are:

- economic
- geographic
- social

These elements vary in significance and strength for different clusters. Some clusters have a strong economic base such as Silicon Valley and Cambridge; others display strong geographic elements, especially those that rely on natural resources such as the timber clusters in the Scandinavian countries, and other clusters display a strong social structure, such as the many industrial districts in Italy. The recognition of these elements allows the identification of clusters that may be deficient in one of the elements but be strong in the other elements. This is particularly useful in identifying clusters that don't have a strong economic presence but have strong social and geographic dependence.

To understand these elements and the role they play in cluster development, it is important to understand the dimensions of these elements.

5.4.2 Cluster Dimensions

An understanding of cluster elements and their associated dimensions allows a framework to be developed that classifies and describes advanced manufacturing regions in Adelaide. Cluster dimensions are sometimes overlooked or not captured in studies on small clusters and/or businesses that are defined by several industry types; the inclusion of cluster dimensions is therefore required and used in this framework. It is important to note that cluster dimensions will vary depending on the cluster and the industry under investigation.

In this framework, the economic element has dimensions that are important to business growth and include:

- innovation

- networks
- economic significance of the region
- business integration in vertical and horizontal industries

The geographic element has several dimensions which encompass the physical aspects of the region and are:

- infrastructure
- location
- natural resources
- distribution and density of businesses

The social element of the framework encompasses dimensions that reflect the role social structures play in business and cluster development and include:

- trust
- knowledge transfer
- regional history
- relationships between businesses and other associations and institutions

The approach used for understanding these dimensions was developed by Enright (1996). This approach, represented in Table 5.7, uses highly specific terminology to describe the activity level of clusters. It covers a wide range of cluster dimensions, but it fails to include one dimension that is important for the present research, the dimension of knowledge base and transfer, and links with universities. Smith (1998) notes that this dimension is important due to the role it plays in a national innovation system and cluster development. This study explores the roles knowledge and knowledge transfer, between businesses as well as between businesses and universities play within advanced manufacturing regions.

Table 5.7: Dimensions used to describe clusters

Dimension	Feature	Activity Level
Geographic	Geographic extent of members	Localised - Tight grouping over small geographic area Dispersed - Spread over wider geographic area
Density	Number and market share of businesses	Dense - Large number of businesses with large market share Sparse - Few businesses with small market share
Depth	Vertically related industries	Deep - related industries and supply chains Shallow - inputs from outside the region
Breadth	Horizontally related industries	Broad - variety of products in closely related industries Narrow - a few industries and their supply chains
Activity Base	Number and nature of activities	Rich - most of the activities are performed locally Poor - few or less of the activities are performed locally
Innovation	Generate innovations that increase competitive advantage	High - large level of innovation Low - small level of innovation
Relationships	Level and type of relationships among clustered businesses	High - extensive and strong relationships between businesses Low - minimal and non-critical relationships between businesses
Growth Potential	Life -cycle of cluster and competitive position of the cluster	Rising - Cluster is growing and could be competitive or non-competitive Peak - Cluster is at its maximum and could be competitive or non-competitive Setting - Cluster is dying and could be competitive or non-competitive

Adapted from Enright (1996)

As for university-industry links, the concept of trust in cluster development is significant (Harrison, 1991). A high level of trust allows business collaborations to be successful and if these collaborations are with universities, businesses are able to develop their knowledge base and increase their level of innovation through the transfer of tacit and codified knowledge. This generally leads to business growth and subsequent cluster development. These are some of the reasons why trust, knowledge and knowledge transfer need to be considered as an essential cluster dimension.

Some clusters have developed through chance (Porter, 1998), region history (Piore & Sable, 1984) and life-style choice (Longhi, 1999). These less documented social dimensions play a significant role in cluster development and so are valid dimensions to consider. Clusters differ from networks in that they comprise relationships that are confined to a geographic space. Relationships within clusters are expected to take place in a local context and under such conditions have an effect on cluster and regional development. Using the cluster elements and dimensions determined in this section, clusters are able to be identified and classified. These cluster classifications are described in the next section

5.4.3 Cluster Classification

As there are a wide range of cluster dimensions for small clusters and industry types that have limited economic significance, a broad and flexible classification approach is required. This section of the framework will allow a number of different cluster types to be identified and described.

Work done by Enright (2000) and Rosenfeld (1996) is important for this study as they classified clusters through their level of business interactions. They have noted that interaction levels may be a critical factor in determining cluster strength. The classification and terminology used are presented below in Table 5.8.

There are other cluster classification approaches that are not governed by the level of relationships; instead they depend on the level and types of production. However this form of classification may miss small or micro clusters and be unable to describe clusters that don’t have an economic significance or cover a number of industry types.

Table 5.8: Cluster Classification

Cluster Classification	Characteristics
Working	Critical mass of businesses, resources, personnel and knowledge
	Interaction betwen businesses in the cluster is different than with businesses outside the cluster
	High and complex levels of co-operation and competition
	View themselves not as an individual business but as a cluster or region
	Able to attract businesses and personnel from other locations
Latent	Critical mass sufficient to gain benefits of clustering
	Insufficient level of interaction between businesses
	Businesses do not veiw themselves as part of region and so don't gain the benefits of co-location
	Attract cluster initiatives to facilitate and increase cluster activity
Potential	Need to be deeper and broader to gain benefits from co-location
	Contain certain elements for cluster development
	Lack of interaction and awareness of working clusters
Wannabe	Lack critical mass
	Often policy driven and chosen by governments for support
	Lack favourable conditions for development into clusters

Adapted from Enright (2000) and Rosenfeld (1996)

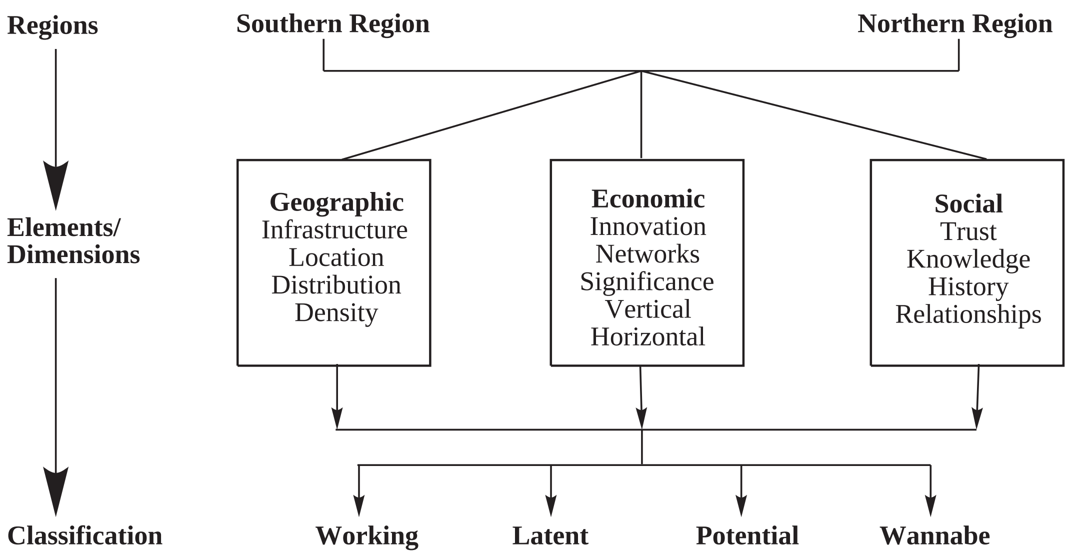
This study utilises the terminology and approach outlined in this section to attempt to describe and classify the advanced manufacturing clusters. The inclusion of potential and wannabe clusters allows for emerging clusters to be identified. This is based on a business realising that it belongs to a cluster and this has a significant impact on how a cluster develops and grows. This is important when cluster analysis is applied to smaller or micro clusters and industries that fall across different industry sectors.

5.4.4 Summary

The framework that has been described is to be used in this study to understand the relationships that occur within clusters.

Both components of this framework draw on approaches used by Enright (1996, 2000) and Rosenfeld (1996). The first component of the framework identifies the different cluster elements and subsequent dimensions. This will identify characteristics that are unique to small clusters and that are visible in certain industry types. These characteristics are specific for this study. The second component of the framework classifies and defines the type of cluster from the identification of the cluster dimensions. This identification will allow for programs and policies to be implemented to increase cluster and regional development and business growth. A representation of the cluster framework is shown in Figure 5.4.

Figure 5.4: Cluster Framework



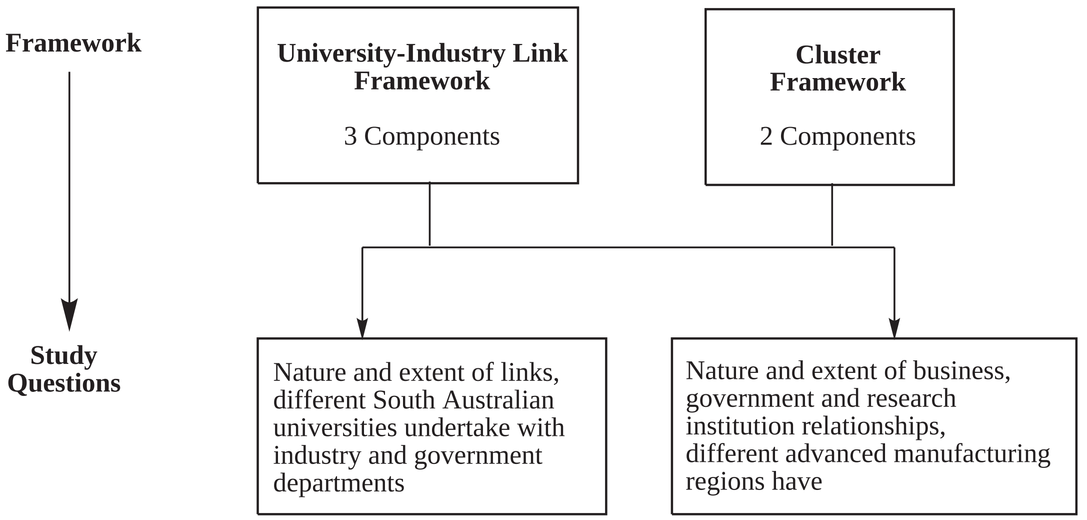
5.5 Study Framework

The development of this framework has been critical and important in organising this study to investigate the phenomenon of university-industry links and clusters. The university-industry framework comprises three components, while the cluster framework consists of two components.

The overall framework allows the study to identify the different characteristics of university-industry links for different universities and the characteristics of business relationships for different advanced manufacturing regions.

The two parts of the framework combine to answer the relevant study questions and are represented in Figure 5.5.

Figure 5.5: Overall Study Framework



The framework directs the study to identify the key elements to answer the study questions.

5.6 Chapter Summary

This chapter has presented the definition of a framework, the rationale for using a framework in this study and the framework that was developed for use in this study. The framework will be used to organise the structure of the study and is not intended to formulate any explicit claims regarding university-industry links and clusters. The framework will be used to identify, explain and examine the specific study areas under investigation.

The framework provides a basis for investigating several important aspects of university-industry links. It will be used to identify different linkage types and the nature of industry partners. The framework will also allow for benefits of university-industry links to be identified and how the level of these links can be increased. The framework provides a method for investigating the key elements and dimensions of clusters that are often overlooked as they are not economically significant or don't have a defined industry type. The description of these elements then allows for the clusters to be identified. The methodology used in this study, which supports the developed framework, is described in the next chapter.

Chapter Six

Research Methodology

6.1 Introduction

This chapter communicates the research paradigm, methodology and analytical framework for this study and provides the necessary support and justification for the approaches used. The methodological scheme incorporates both areas of research of university-industry links and clusters. It has been used to provide both qualitative and quantitative data to understand the nature and extent of industry links in regions (Chapter 8). It has also yielded relevant data concerning the type and level of university-industry links for the three universities (Chapter 7).

The chapter describes the data collection methods used, together with the basis for the style of questionnaire used. The validity and reliability of the approach is discussed as well as the different triangulations used to validate and support the findings.

6.2 Research Approach

In the area of clusters, most research has focussed on the position of clustered firms in the economy and the advantage businesses obtain from being co-located. This research has consisted primarily of quantitative analysis of economic data to identify concentrations of factors such as production, exports and R&D (Braunerhjelm & Carlsson, 1999; Porter, 1990, 1998; Feser & Bergman, 2000). This type of analysis has been constructive in comparing regions, but hasn't imparted any insight on the interactions between businesses within defined clusters.

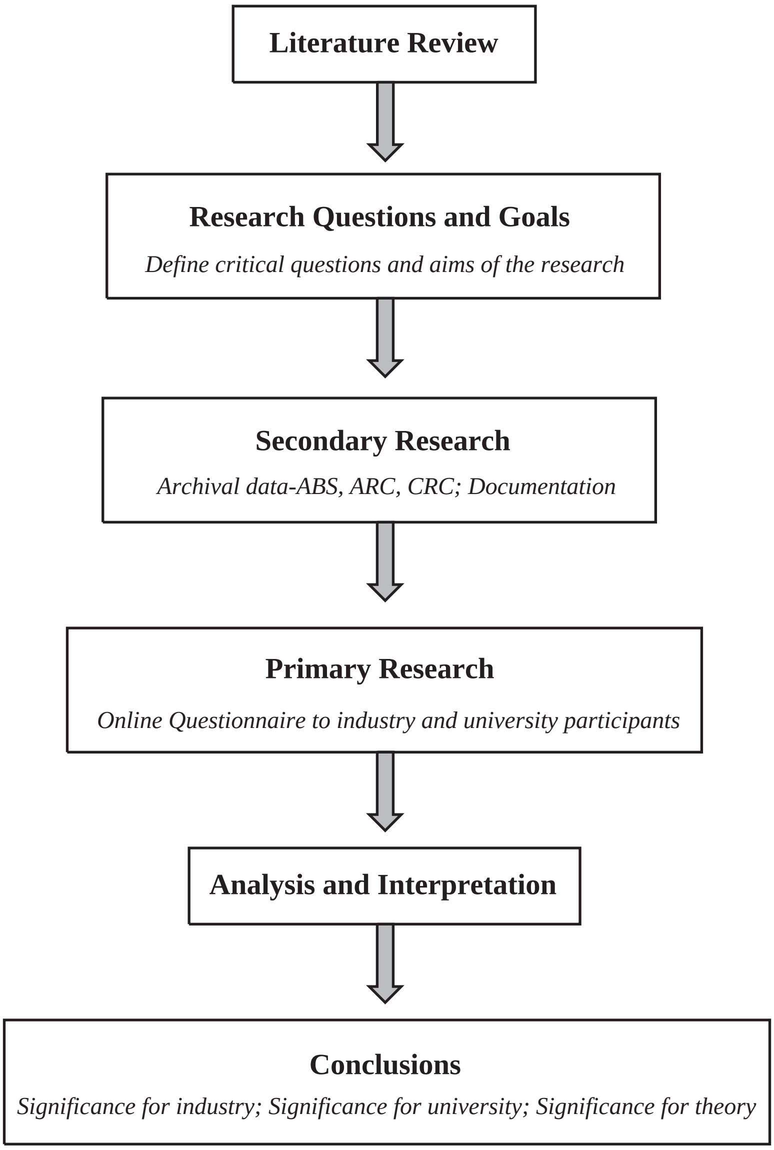
These interactions have a large effect on cluster success, as well as the success of individual businesses within a cluster. Intra-cluster interactions can involve formal and informal links between businesses, universities and government bodies and the extent and success of these links needs to be researched and understood. Research into cluster links has been conducted on internationally located clusters, but the research on Australian clusters is limited. Longhi (1999) studied the Sophia-Antipolis region within France, simiarily Keeble *et al.* (1999) investigated the links between, and advantages of, businesses located around the University of Cambridge. In all cases, research into cluster links involves the collection of an extensive amount of diverse data, such as economic data, location data, innovation and R&D data and data on the social factors.

The research conducted on university-industry links in Australia has been centred primarily on the benefits and risks of academics undertaking research links with industry (Turpin *et al.* 1996; Harman, 1999, 2001, 2002). This type of research has proven useful in comparing industry funded academics to non-industry funded academics at three major universities. The key characteristics of industry funded academics, success levels of industry partnerships and the benefits and risks associated with academics working with industry were investigated. However the results did not provide an insight into the different industry links undertaken by local universities and the subsequent location of the industry partners. The study also failed to highlight the different opinions of academics employed at differently aligned universities, in relation to university-industry links.

As discussed earlier, this study is divided into two sections. The first describes the nature and extent of university-industry links within the three South Australian universities. These links will be classified by research field and industry partner location which will allow for a determination of possible strengths and weaknesses of the university in relation to university-industry links. For both sections an extensive quantity of both quantitative and qualitative information from multiple primary and secondary sources is required to gain a critical insight into industry-industry links and university-industry links.

This will be achieved via a series of related steps (Figure 6.1).

Figure 6.1: Research Approach



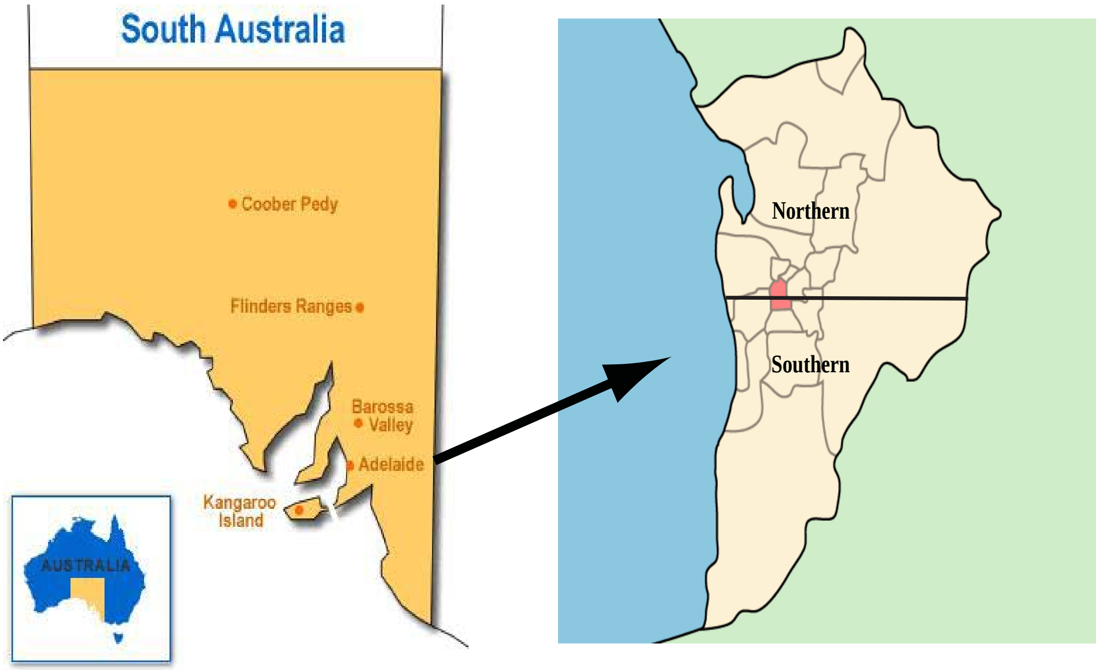
6.3 Study Locations

This study is divided into two main components. The first component of the study involves the three South Australia universities: University of Adelaide, Flinders University and University of South Australia. The second part of the study concerns the different manufacturing regions of Adelaide which are north and south of the Central Business District (CBD).

6.3.1 Industry regions

The two industry study areas are introduced below and are shown in Figure 6.2. They involve different local government bodies whose boundaries are shown in Figure 6.2, and can be seen in more detail in Appendix A. Some of the local government bodies are situated in more than one of the study areas.

Figure 6.2: Location of two industry study areas in Adelaide



Adelaide Central Business District (CBD) in red.

6.3.1.1 Southern Industry Study Area

The southern region of Adelaide comprises a large area and encompasses the Cities of Onkaparinga, Marion, Holdfast Bay and West Torrens, and the Fleurieu region which comprises the City of Victor Harbour, the District Council of Yankalilla and Alexandrina Council. The largest employment sectors are manufacturing, retail trade, health and community services, education and construction. In terms of employment, all of the sectors except for construction are relatively larger in the southern region than the equivalent sectors in the State economy.

The region has a strong manufacturing history, with this sector providing 18 percent of both employment and value added products. In comparison, manufacturing contributes 15 percent to employment and 14 percent value added to the State. A feature of the southern region economy is that it is dominated by Small to medium enterprises (SMEs); over 95 percent of businesses are SMEs. Economic analysis of the southern region shows that its gross regional product (GRP) in 2004 was around $7.3 billion which represents 14.1 percent of South Australia's Gross State Product (GSP).

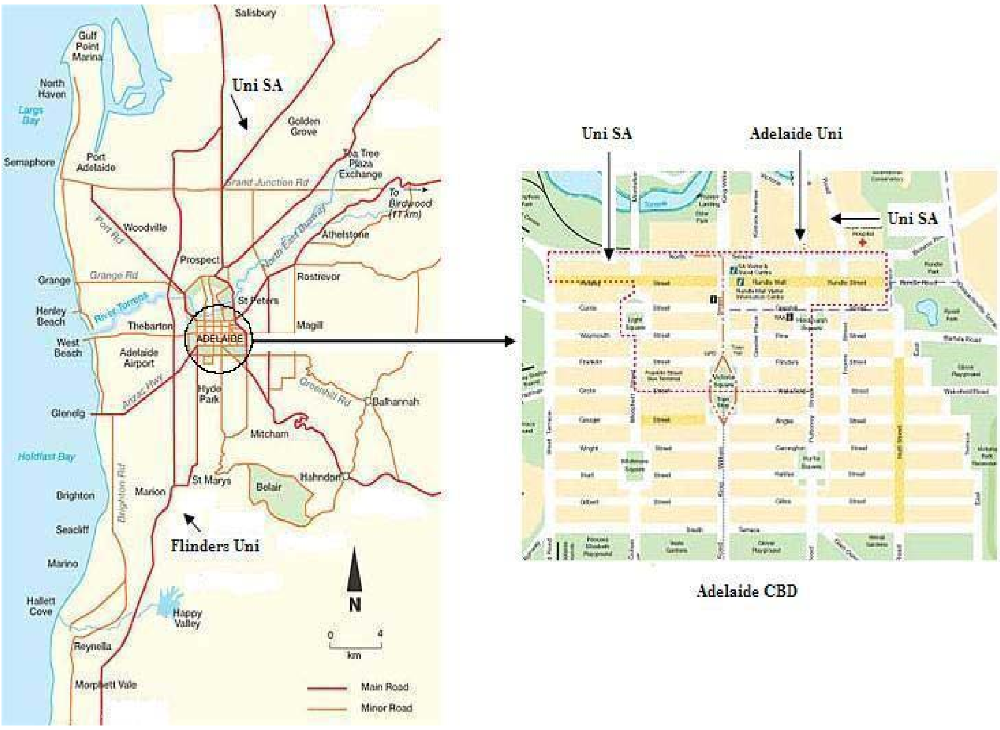
6.3.1.2 Northern Industry Study Area

The final study area covers the northern area of Adelaide and comprises the local government areas (LGAs) of the Cities of Salisbury, Playford, Port Adelaide, Charles Sturt and Tea Tree Gully. The area has a strong manufacturing sector and is home to some of the nations leading advanced and high technology manufacturers in the sectors of defence, electronics, automotive, software, food processing and pharmaceuticals. It is home to the internationally recognised defence cluster, technology park and the new shipping building cluster, where new Australian naval ships will be built. It is one of the fastest growing commercial and residential areas in South Australia.

6.3.2 South Australian Universities

The universities of Flinders, Adelaide and South Australia are the only local universities in Adelaide, along with the Australian campus of the international university Carnegie. The local universities attract a large number of international students to Adelaide. All three universities are committed to producing world class graduates through fundamental research teachings and increasing collaborations with industry and business. The campus locations of the different universities are shown in Figure 6.3.

Figure 6.3: Main campus locations of the three universities



6.3.2.1 *Flinders University*

Flinders University was established in 1966 and its main campus is located south of the Adelaide Central Business District (CBD) at Bedford Park. It has external teaching facilities in Port Lincoln, Renmark, Mt Gambier, Darwin, Alice Springs and Warrnambool. It is a key member of the Innovative Research Universities Australia alliance. In 2006, the university had a total enrolment of 15,110 students and 631 academic staff. The university is comprised of four faculties which offer 170 undergraduate and postgraduate courses. The university ranks among Australia's top universities in research spending on a per capita basis and in the citation of work in professional journals.

6.3.2.2 University of South Australia

University of South Australia (Uni SA) was founded in 1991 through the amalgamation of the South Australian Institute of Technology (SAIT) and the Magill, Salisbury and Underdale campuses of the South Australian College of Advanced Education (SACAE). Its main campuses are in the Adelaide CBD as well as Mawson Lakes which is north of the Adelaide CBD. The university also has campuses at Whyalla and Mount Gambier. Uni SA is a member of the Australian Technology Network (ATN). The university employed 955 academics and had a student enrolment of 33,722 students in 2006. The university is comprised of four divisions which offer over 180 undergraduate and postgraduate courses.

6.3.2.3 University of Adelaide

The University of Adelaide was established in 1874 and is the third oldest university in Australia. Its main campus is located in the Adelaide CBD, but it also has campuses north and south of the CBD. The university consists of five faculties, which offer about the same number of undergraduate and postgraduate courses as Flinders and Uni SA. The university is ranked in the top 1% of universities in the world in 11 research fields. It is a member of the Group of Eight universities (Go8). In 2006 the university had a student enrolment of 19,646 and employed 1,207 academic staff.

6.3.3 Industry Partners

The industry partners involved in this study are the City of Onkaparinga and the Fleurieu Regional Development Board (FRD). They initiated this study through an ARC (I) Linkage Project as well as providing contacts, data and resources essential for this study. These partners represent two council areas in South Australia and view the study as a means to understanding the advanced manufacturing industry in their regions and the links this industry has with other industries and universities. It is hoped that an understanding of these links and industries will strengthen and increase economic development in the southern regions of Adelaide. The Marion City

Council has acted as a quasi industry partner in this study with a view of obtaining the same benefits as the official industry partners.

The Marion City Council and City of Onkaparinga have formed a partnership in a new Southern Region Economic Diversification Blueprint. Although this study is focused on particular regions in Adelaide and universities, it is important to recognise and understand that the level and importance of these industries and relationships vary across regions and between universities.

6.4 Research Paradigm

There are two main research paradigms used in research, being positivist and phenomenological. These paradigms have a few alternative terms which are listed in Table 6.1, but for this research the above mentioned terms will be used.

Table 6.1: Alternative terms for the main research paradigms (Hussey & Hussey, 1997)

Positivistic Paradigm	Phenomenological Paradigm
Quantitative	Qualitative
Objectivist	Subjectivist
Scientific	Humanistic
Experimentalist	Interpretivist
Traditionalist	

Positivist research used in social sciences is based on the approach used in natural sciences (Hussey & Hussey, 1997; Cavana *et al.* 2001). This type of research assumes that there is a set of fixed laws which bind both the natural and social worlds in a sequence of cause and effect. (Easterby-Smith *et al.* 1991; Hussey & Hussey, 1997; Cavana *et al.* 2001).

For the social sciences the assumption is that the social world is independent of us and exists regardless of whether we are aware of it (Hussey & Hussey 1997).

Remenyi *et al.* (1998) suggests the use of positivism in the social sciences leads to two possible limitations:

- not regarded as an approach that will lead to interesting and profound insight into complex problems.
- some of the complicating factors and interesting factors have been removed due to the simplification of the real world by this approach.

Positivistic research uses deductive reasoning by beginning with a theoretical position and then moving towards concrete evidence to establish causal relationships between the variables. This research uses precise, objective measures, usually is associated with some type of measurable data, but does not take into account the subjective state of the individual. Overall the positivistic approach in social sciences has become synonymous with deductive approaches and theory examination (Easterby-Smith *et al.* 1991).

Phenomenological research is defined by Hussey & Hussey (1997) as being "concerned with understanding human behaviour from the participant's own frame of reference." Unlike positivist research, which assumes people share the same system, phenomenological research assumes that people experience physical and social reality in different ways, so no set of fixed laws describes everyone. The phenomenological researcher "assumes the world is largely what people perceive it to be and therefore reality is socially constructed" (Cavana *et al.* 2001, p 9.). Each phenomenon or situation is seen as unique and its meaning is a function of the individuals involved and the circumstances of the situation (Remenyi et al., 1998).

The phenomenological paradigm is sometimes described as the descriptive/interpretative approach (Remenyi *et al.* 1998) and has become synonymous with qualitative data and induction.

The methods used under this approach are interpretative techniques which seek to describe and translate the meaning of a phenomenon and not its frequency (Hussey & Hussey, 1997). This research approach unfolds as the research proceeds.

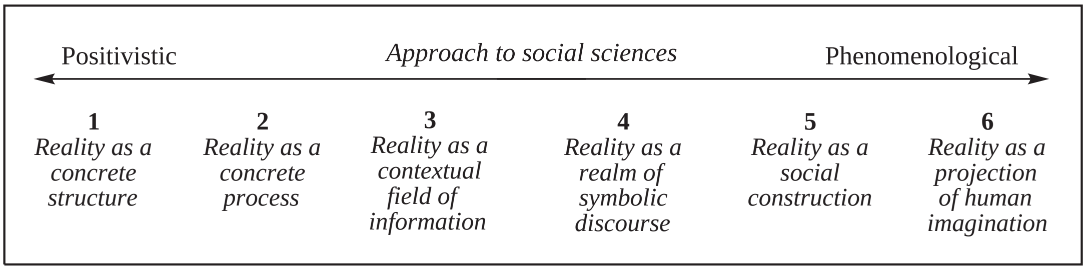
The researcher determines and identifies what is important to the individual, which then allows the researcher to uncover the meaning of the phenomenon as understood by an individual or a group of individuals. Phenomenological research is interpretive, pragmatic and essentially grounded in the lived experiences of people (Marshall & Rossman, 2006). The main features of the two paradigms are summarised in Table 6.2.

Table 6.2: Features of the two main paradigms (Hussey & Hussey, 1997)

Positivistic Paradigm	**Phenomenological Paradigm**
Tends to produce quantitative data	Tends to produce qualitative data
Uses large samples	Uses small samples
Concerned with hypothesis testing	Concerned with generating theories
Data is highly specific and precise	Data is rich and subjective
The location is artificial	The location is natural
Reliability is high	Reliability is low
Validity is low	Validity is high
Generalises from sample to population	Generalises from one setting to another

It must be understood that the above two paradigms are diametrical opposites and so there exists a continuum between these two positions. Morgan and Smircich (1980) identified six stages in this continuum (Figure 6.4). This study involves both quantitative and qualitative data and so comfortably fits in between stages three and four.

Figure 6.4: Continuum – six stages



There are three major types of studies which are defined as monomethod studies, mixed method studies and mixed model studies (Tashakkori & Teddlie, 1998). This study uses the mixed method approach which can be further divided into five different types:

- sequential studies
- parallel/simultaneous studies
- equivalent status designs
- dominant-less dominant studies
- designs with multilevel use of approaches

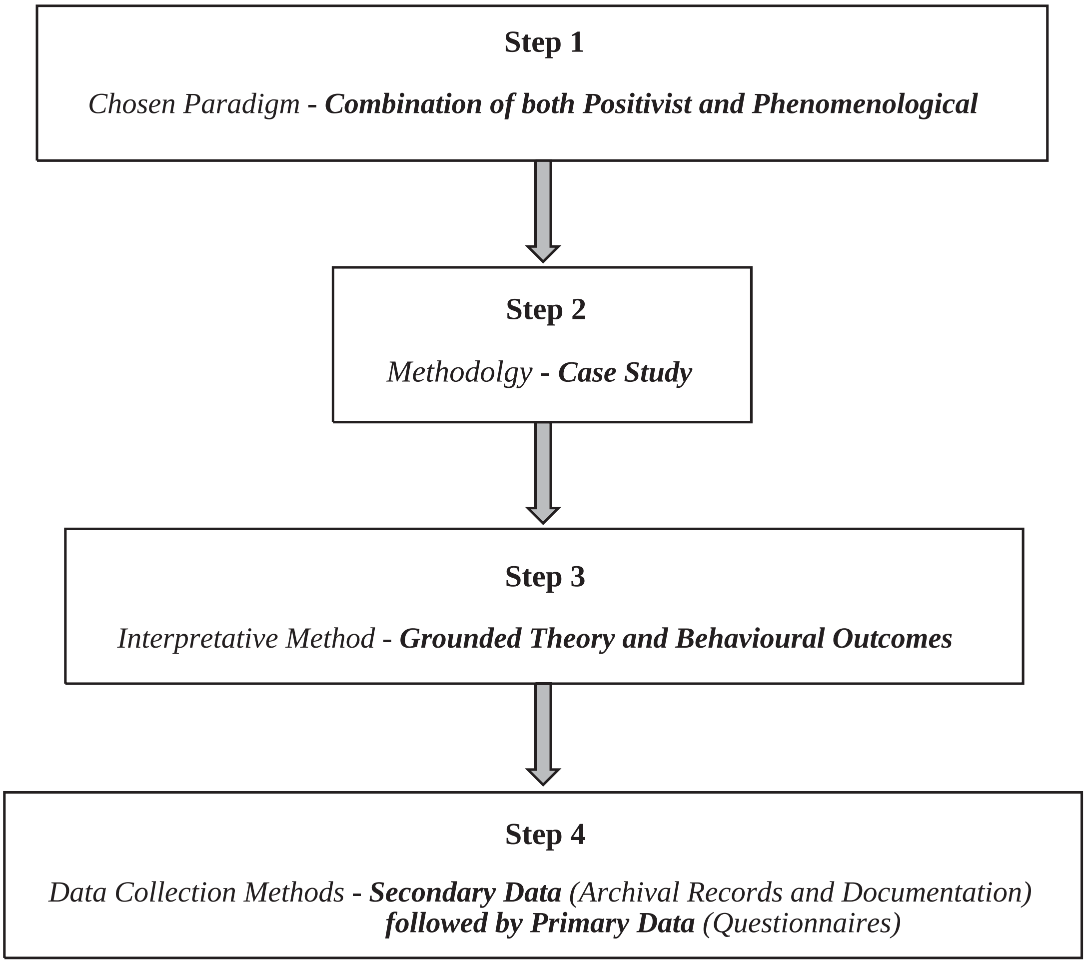
This study uses the parallel/simultaneous mixed method approach, collection of which involves the quantitative and qualitative data at the same time and analysis the data in a complementary manner (Tashakkori & Teddlie, 1998). This approach generates the required numerical and narrative data that answer similar questions.

As this study is attempting to fully investigate the desired research questions, the study has a research paradigm that incorporates some aspects of both positivistic and phenomenological paradigms.

6.5 Methodological Approach

The methodological approach for this study entails a number of steps and includes a range of data collecting means. The framework of this methodological approach shown in Figure 6.5 succinctly shows the desired steps the research methodology will take.

Figure 6.5: Pathway of the framework for the methodological approach



6.4.1 Case Study Strategy

A case study for both research areas has been selected as the most effective way to accomplish the study. Both qualitative and quantitative data will be collected under the case study scenario as the research will determine who, why and how answers.

Case studies are used as an evidence collection approach and allow for the presentation of a range of different data sources. This doesn't commit the researcher to either a positivistic or phenomenological strategy (Remenyi *et al.* 1998). Case studies have two distinct features being firstly the establishment of valid and reliable evidence and secondly the explanation of the observed phenomena.

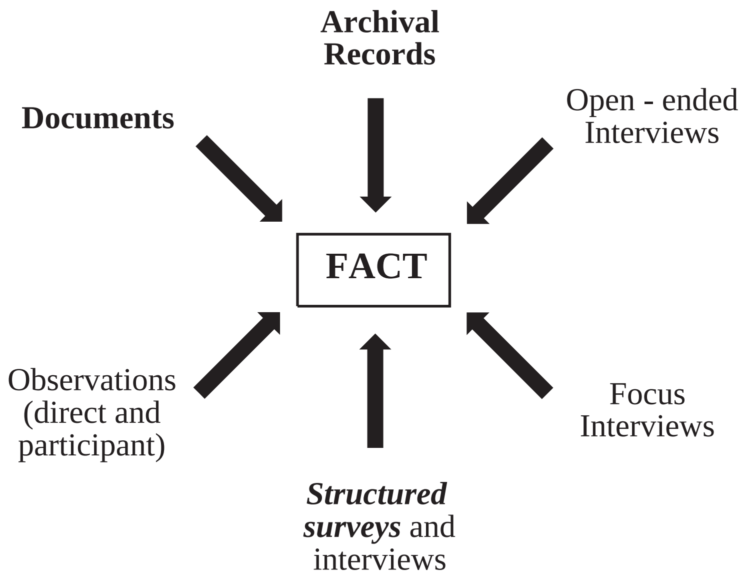
A definition of a case study by Yin (2003) is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used. This approach of combining quantitative and qualitative data from multiple sources has been used in this study. The use of different research approaches, methods and techniques in the study can address the problems of bias, reliability and construct validity found in a single-method approach (Hussey & Hussey, 1997) and produce higher quality findings.

This triangulation is multiple sources of evidence and methods providing multiple measures of the same phenomenon (Patton, 1990; Yin, 2003). Easterby-Smith *et al.* (1991) identified four types of triangulation:

- data (use of different data sources)
- investigator (use of different researchers)
- methodological (use of multiple methods to study a problem)
- theories (use of multiple perspectives to interpret the results)

The multiple sources and nature of evidence collection allows for information convergence. Figure 6.6 adapted from Yin (2003, p. 100) highlights how the phenomenon can be studied by the convergence of multiple data sources. This study will use data and methodological triangulation for each of the case studies.

Figure 6.6: Convergence of Multiple Sources of Evidence



Note: Sources used in this study are in bold and italics

Yin (2003) has noted that there are limitations to a case study approach with one important limitation being its inability to make generalisations about a subject. This is only important if this study was attempting to formulate a generalised theory relating to industry-industry and university-industry links which it is not.

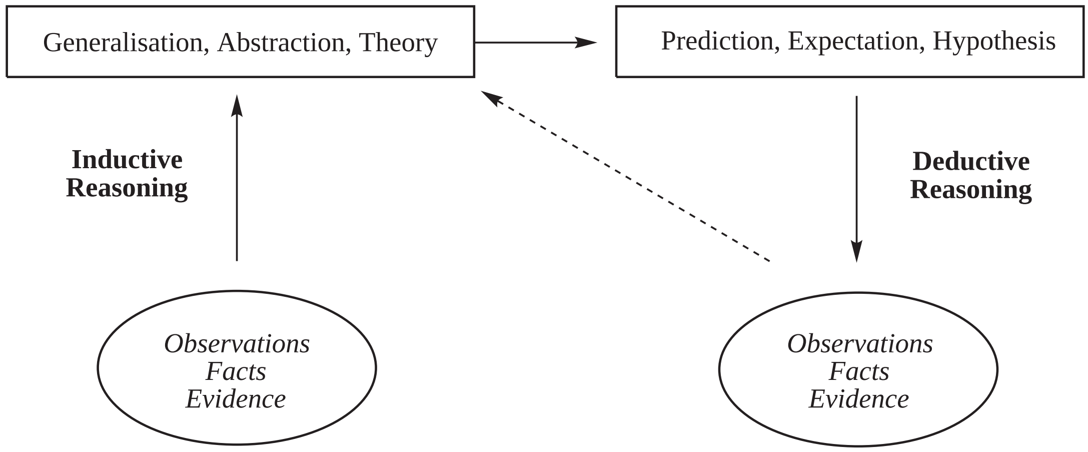
Another limitation is the ability of the participants to recollect previous events and perceptions of current events that may lead to incorrect answering of questions. These limitations are recognised and the study addresses them by using multiple case studies as well as the use of data triangulation which will minimise errors in questions that rely on the participant's memory.

6.4.2 Interpretive Approach

For both sections of this study the collection and analysis of data concerning industry-industry links and university-links followed an adapted theory based on a combination of induction and deduction approaches (Strauss & Corbin, 1990, Strauss, 1987).

The adapted approach for this research uses both inductive and deductive reasoning to generate theories and conclusions. This is due to the fact that in research it is difficult to discount already established theories concerning the research that is being undertaken. Tashakkori & Teddlie (1998, p25) point out that "at some points during the research process, it is likely that both types of inferences and methods will be used simultaneously." This use of both methods of reasoning (research cycle) can best be displayed by Figure 6.7 which shows the relationship between induction and deduction (Tashakkori & Teddlie, 1998).

Figure 6.7: The Research Cycle (Tashakkori & Teddlie, 1998)



This adapted approach with both induction and deduction was used in this study in the context that at the start of the study the initial theory determined what data should be collected and subsequent data collection and analysis phases was determined from the previous step. This approach allowed for the research steps of the study to be in a quasi state of flux. This quasi state of flux allowed the theory determination and research steps to be modified to the benefit of the study through observation of the data from preceding steps.

Also used in the interpretative method was the concept of behavioural outcomes which is grounded in theory of bounded rationality (March & Simon, 1958).

In this method, people tend to look at the outcomes of collaborations in terms of benefits that are not quantitative and evaluate them as:

- positive or negative
- satisfactory or unsatisfactory
- significant or insignificant
- strong or weak

These behavioural measures play an important role when business people or academics undertake collaborations with other people as they do not actually try to maximise their values by employing economic calculations but rather look for good enough situations (Lee, 2000).

6.4.3 Data Collection

As stated previously in this chapter both quantitative and qualitative methods are being used in this study. The quantitative data will identify key characteristics of both industry-industry links and university-industry links and allow for the different manufacturing regions and universities to be compared. This quantitative analysis will be combined with the qualitative data of the case studies. This mutual confirmation will determine the overall conclusions for both sections of the study. It was decided that due to the study having two sections, there would only be one form of data collection being the questionnaires and there would be no data collected via interviews. Some of the data collected in this questionnaire are dynamic in nature and so are subject to evolution and refinement over time.

6.4.3.1 Sample Selection

The selection of the two manufacturing regions of Adelaide means that differences in these regions can be analysed and compared on a region basis and an industry basis. The regions were chosen as they are major manufacturing regions of Adelaide and so best represent an overall picture of industry-industry links and outcomes of this research may aid these regions in increasing economic prosperity. The three universities were selected as they are all local and also represent universities that are aligned to three different groups of universities as discussed in preceding chapters. This selection of these universities will allow university-industry links to be analysed and compared on a faculty basis and university alignment basis. The outcomes may have some application by allowing each individual university to understand their links with industry and increase and enhance these links.

Two main data collection methods were used. The first method was an assemblage of all relevant secondary data such as archival records, databases and documents. This data was analysed to provide background facts on the study as well as a data source to reinforce the findings from the primary data. These will be further explained in this chapter. The second data collection method was for the primary data and involved a questionnaire targeted to all participants who were considered relevant for the study.

For the university study the participants were identified as all academics at the universities whether they had been involved in university-industry linkages or not. This wide sweep of all participants allowed for a broad depth of data to be gathered to be used in the case studies. This wide sweep process is known as judgemental selection (Hussey & Hussey, 1997) as the participants are identified and selected on the strength of their knowledge and experience of the phenomenon under study. This type of selection means the researcher doesn’t pursue any other participants which may arise during the course of the study. This rich data provides a valuable resource for the individual universities to understand the nature and extent of these linkages and to act in areas to improve them if they so desire.

For the industry study the participants were selected based on their involvement in the select industry type and regions. This was also a questionnaire aimed at covering all players involved. The industry partners view this data as a possible resource they can use to understand the nature and extent of industry links in there area.

6.4.3.2 Secondary Data

Secondary data is considered to be indispensable in business research (Cavana *et al.* 2001). Archival records, survey data, relevant databases can all be used in conjunction with other evidence sources in case study research (Yin, 2003). There was a wide range of secondary data used in this study to augment the primary data obtained via the questionnaire.

For the university study, secondary data used was obtained from the ARC and CRC. The ARC data used covered all successful ARC Linkage from the years 2001 to 2006. This data was used to calculate locations of industry partners for universities and whether universities specialise in certain research fields. The CRC data was used to investigate the number of CRC's that different universities are involved in. This data and findings will be discussed further in Chapter Seven.

In the industry study, secondary data was obtained from the ABS. The ABS data covered Journey to Work figures from the last two censuses (2001 and 2006) which allowed for calculation of location quotient for the specific region. Also used were innovation data and manufacturing data from the annual ABS year book. As with the university secondary data this will be discussed in greater depth in Chapter Eight.

6.4.3.3 Questionnaire

The essential purpose of questionnaire research is to obtain information that cannot be easily observed or that is not already available either in written or computer form (Remenyi *et al.* 1998). They are a list of specific set of written questions to which respondents record their coded answers within closely defined alternatives. They are one of the most common and efficient forms of collecting data (e.g. ABS Census) and are common in both positivist and phenomenological research paradigms. There are several ways of administering questionnaires such as personally to respondents, mailed to respondents, electronically distributed through email or via a web site (Cavana *et al.* 2001).

Questionnaires can contain open-ended and closed questions or a combination of both. Each question can be coded at the design stage so completed questionnaires can be easily analysed depending on the responses for each question. A positivistic paradigm direct the questionnaire to have closed ended questions while a phenomenological approach directs towards open-ended questions (Hussey & Hussey, 1997). "The choice of open or closed questions depends on many factors such as the question content, respondent motivation, method of administration , type of respondents……there is no right or wrong approach" (de Vaus, 2002, p. 100).

A closed or forced choice question is where the respondent's answer is selected from a number or predetermined alternatives. These alternatives can range from a simple yes or no to the Likert scale which determines their level of agreement with a specific statement. These questions are difficult to design but are generally quick to answer, easier to code, produce less variable answers and allow the answers to be meaningfully compared due to the limited number of potential answers. The main drawback of closed questions is they can create false opinions due to an insufficient range of alternatives or causing the respondents to give answers they would not give if they could respond in their own words (Foddy, 1994)

Open questions are questions were the respondent can give a response in their own words. These questions are easy to design and allow for more complex answers but generally require the respondent to be articulate and take more time to give a full answer to the question (Remenyi *et al.* 1998). The main disadvantages are the questions produce more variable answers which are more difficult to analyse.

The questionnaires used in this study were based on an extensive literature review and existing questionnaires undertaken in the research areas (Austrian, 2000; Harman, 1999; Blumenthal *et al.* 1986, 1996; UK Innovation Survey, 2002; Keeble et al., 1999). This basis allowed for the questions to be specifically tailored for case studies investigated in this study.

It was decided to use a computer administered questionnaire via a specific web site for both research sections. This form of questionnaire distribution is being increasingly used due to the enormous power and flexibility of designing web questionnaires (Dillman, 2007). The advantages of this approach are its low cost, ease at which it can be administered and instantaneous evidence collection and analysis (Remenyi *et al.* 1998). The main disadvantage is the sample being restricted to users of the internet and computer literate but it was assumed that the participants due to their specific business roles and academic roles would have access to the internet, email and be versed in using a computer. This access would allow them to receive the introduction email requesting them to volunteer their time to participate in the questionnaire.

For the research on industry links only one questionnaire was developed, while for university-industry linkages research two questionnaires were developed; one to each participating university. The questions in each of university-industry linkages are the same with the only difference being the questions relating to the specific faculties, schools, departments and divisions for each university.

In the case of the business questionnaire the questionnaire was directed to a manager or senior personnel of the business, as they were considered to be the best participant for answering the questions and providing the best obtainable results. They would have in depth and critical knowledge of the nature and extent of their business relationships as well as their levels of innovation. The questionnaire was divided into four main topics:

- key features of the business
- importance of business location and links with other businesses
- factors affecting business growth
- nature and importance of collaborations with universities

The university questionnaire was distributed to academics at the two South Australian universities, as they are in the best position to comment on the nature of collaborations and links they have with industry partners.

This questionnaire was divided into three main topics:

- profile of the academic
- nature and importance of collaborating with industry partners
- opinions on the benefits and risks of collaborating with industry

Appendix D contains both of these questionnaires in their entirety.

There are always issues of bias in questionnaire responses due to the non-return of questionnaires and non-response of certain questions in the questionnaire by participants. This bias was anticipated and to some extent rectified by attempting to maximise the response rate through a two reminder emails asking the participants to complete the questionnaire.

Non-sampling errors may also arise in this study and are a result of errors in the reporting, recording or processing of the data from the questionnaire. These errors can be introduced due to questionnaire faults and errors in data capture and processing. These errors have been minimised by careful design and testing of the questionnaire, efficient operating procedures and use of the appropriate research methodology.

The response rate for the university questionnaire was 29.55 percent for Flinders University and 20 percent for the University of Adelaide. The response rate for the industry questionnaire was 30 percent for the southern region and 35 percent for the northern region. The number of responses and response rate for each questionnaire in each case study are detailed in Table 6.3 and Table 6.4.

Table 6.3: Response Rates for University Questionnaire

	Flinders University	**University of Adelaide**
Number Distributed	450	400
Response	133	80
Response Rate %	29.55	20

Table 6.4: Response rates for Industry Questionnaire

	Southern Region	Northern Region
Number Distributed	92	88
Response	28	31
Response Rate %	30	35

6.4.3.4 Data Analysis

As both quantitative and qualitative data were collected a combination of analytical techniques will be used to analyse and report on the data. This combination allows for data to be analysed to its maximum use. The qualitative data was analysed by investigating the frequency and nature of responses from the open-ended qualitative questions contained in both questionnaires. These responses were used as a basis of descriptive material for the case studies. The quantitative data from both the questionnaires and secondary sources was analysed using Microsoft Excel®* and SPSS®** statistical package.

Similarities and differences were identified for each section of the study. Descriptive statistical analysis of the quantitative data from the questionnaire allowed for these similarities and differences between the manufacturing regions and the universities to be determined. Mean values from the 5 point likert scale were tested to determine if the differences in the values are of statistical significance.

The general hypothesis was that the means in the populations are not different from each other, and depending on the corresponding p-value this was either accepted or rejected.

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* Microsoft. One Microsoft Way, Washington State

** SPSS UK Ltd. First Floor, St. Andrews House, West Street, Surrey

The level of significance in the quantitative data analysis for this study is denoted by the p-value. This p-value represents the probability of a difference occurring between groups. Normally the null hypothesis is rejected if the p value is less than 0.05, but a p-value of 0.1 is accepted in social science research and this is the value that will be used in this study.

A p-value of 0.1 or greater implies that the statistic is significant beyond the 10% level and so the null hypothesis is accepted and so there is no significant difference between the groups. If the p-value is less than 0.1 the null hypothesis is rejected and it is assumed that the difference between the groups is statistically significant.

If the p-value is very small, the difference is highly statistically significant. When there is a significant difference at the 10 percent level, this is equal to a 90% confidence that the differences are significant and that the result is not due to chance. A p-value of 0.05 is equal to a 95% confidence level and when $p=0.01$, there is 99% confidence that the differences are significant. The analysis for each section of the study will be discussed in the next two chapters.

6.5 Strengths and Limitations

With the above sections justifying the research methodology used, this section will review the methodology in terms of its strengths and limitations. These are generally summed up under the umbrella terms of internal validity, reliability and external validity (generalisability) of the methodology. These terms take on different meanings depending on whether the paradigm is positivist or phenomenological. The terms validity and reliability have generally been associated with quantitative research and have been reluctantly applied to qualitative research (Hussey & Hussey, 1997). This difference in meanings has been best described by Easterby-Smith *et al.* (1991) and is detailed in Table 6.5.

Table 6.5: Questions of reliability, validity and generalisability (Easterby-Smith et al. 1991)

	Positivist Viewpoint	Phenomenological Viewpoint
Validity	Does an instrument measure what it is supposed to measure?	Has the researcher gained full access to the knowledge and meanings of the informants?
Reliability	Will the measure yield the same results on different occasions (assuming no real change in what is to be measured)?	Will similar observations be made by different researchers on different occasions?
Generalisability	What is the probability that patterns from observed in a sample will also be present in the wider population which the sample was drawn?	How likely is that ideas and theories generated in one setting will also apply in other settings?

Hussey and Hussey (1997) imply that the level of validity and conclusions obtained from qualitative research is related to the richness of information the researcher gathers during the collection period. All researchers desire and aim to achieve high levels of data validity, reliability and generalisability.

As these concepts are important and very significant in this study, the methodology has been refined to maximise the validity of the results and the reliability and external validity of the conclusions.

6.5.1 Validity

Validity is defined as "the degree to which what is observed or measured is the same as what was purported to be observed or measured (Remenyi *et al.* 1998). There are three methods (Yin, 2003) which can increase validity:

- triangulation (multiple sources of evidence)
- chain of evidence during data collection
- questionnaire protocol reviewed by key informants

It is also essential that the questions asked in the questionnaire are consistent with the study explanation given to the supervisor (Hussey & Hussey 1997)

Using both qualitative and quantitative methods and information obtained from existing questionnaires, archival data and secondary data sources the primary data was able to be triangulated. The case study approach and methodology was validated by staff at Flinders University. This validation was achieved by reviewing the questionnaire purpose and design, methodology, data collection and research questions. This was accomplished by formal presentations to staff and industry partners, supervisor meetings and discussions with other researchers in the field.

The questionnaires were initially tested with 10 fellow PhD students in the School of Chemistry, Physics and Earth Sciences at Flinders University to confirm that the online questionnaire could successfully be viewed and completed and that they could clearly understand the purpose of the study and related questions. This testing revealed several spelling errors and one technical error. These were fixed and then trialled again on several academics in the same school to ensure the questionnaires were clear and effective in obtaining the relevant and desired information. No more problems were identified and the questionnaire was ready for distribution.

6.5.2 Reliability

Reliability is defined as “the degree to which observations or measures are consistent and stable” (Remenyi *et al.* 1998, p181). The goal of reliability is to minimise the number of errors and biases that arise during the study (Yin, 2003). This can be accomplished in a case study based research by maintaining a chain of evidence. This chain of evidence involves developing a sound database, documentation of procedures and a reliable case study protocol. A good chain of evidence can be achieved by the researcher by making sure that as many steps as possible are operational. Yin (1993) suggests that the achievement of the above chain of evidence will allow the reader of the case study to follow the derivation of any evidence, ranging from initial research questions to ultimate case study conclusions in either direction.

Remenyi *et al.* (1998) suggests that a positivist using case studies will claim reliability but a phenomenologist will not regard this issue as pertinent and that some will claim that as all situations and organisations are unique the same results can't ever be obtained again. This reliability deficiency has been minimised in this research by developing a well defined research framework that included clear documentation at each step, clear research questions and procedures and a sensible methodology.

6.5.3 External Validity

External validity or generalisability is defined as "the characteristics of the research findings that allow them to be applied to other situations and other populations (Remenyi *et al.* 1998, p283). Due to the unique and specific individual links that businesses and universities undertake it would be difficult to generate generalised theories on this subject. This uniqueness of situations is the basis of Cronbach (1975) concept of a working hypothesis. Cronbach (1975) argues that there are always unique factors that make any generalisation a working hypothesis, not a conclusion. This implies that the researcher must provide a 'thick description' of the research context and phenomenon found (views, experiences, processes) to allow others to decide the transferability of the conclusions to another setting (Ritchie & Lewis, 2003).

The research undertaken in this study strives to provide a sound base of information which will allow for some level of transferability. This base of information will be useful in reinforcing concepts that have risen from other research in these areas, even though a generalised theory was not developed from this study. A working hypothesis can be formulated from this information base which will have implications in business policy and university collaborations for the particular regions and universities.

6.6 Chapter Summary

This chapter has clearly described and justified the research methodology used in this study. The use of both a positivist and phenomenological paradigm has allowed for the capture of the critical and complex factors involved in industry-industry links and university-industry links. The case study approach for both sections of the study was acceptable and the use of data triangulation provides the research with a clear and reliable methodology to investigate the phenomenon.

The intent of the research is to identify the nature and extent of industry links with other businesses and the nature and extent of university links with industry by analysing regional and university case studies. By approaching this with both quantitative and qualitative analysis a degree of comparable and representative sets of critical factors will be produced. The identification of these critical factors will hence allow for theories to be developed.

The next two chapters contain the results of the secondary data and the questionnaire for each of the case studies. Chapter Seven comprises the analysis of both the quantitative and qualitative data which allows for the presentation of the similarities and differences between the South Australian universities concerning university-industry links. Chapter Eight presents the similarities and differences of the two advanced manufacturing regions concerning inter-business relationships in a similar manner as Chapter Seven.

Chapter Seven

University Case Study

7.1 Introduction

This chapter discusses and interprets the data on university-industry links collected from both secondary and primary sources for the South Australian universities. The chapter is organised by first analysing the levels at which the universities participate in the CRC program and ARC Linkage grant program. This is followed by an analysis of the key survey responses from the academic participants from Flinders University and University of Adelaide. The University of South Australia chose not to partake in the research, but by using data available from the CRCs and ARC participation, the nature and level of their industry collaborations can be deduced, but not the same depth as for the other universities.

This case study is investigated using quantitative and qualitative data. The quantitative data is derived from the closed ended questions of the questionnaire and also the ARC Linkage grants and CRC program data, available from the corresponding websites. The qualitative information is based on the open-ended responses of participants from the questionnaire. The data is analysed using descriptive statistics. This approach was outlined in Chapter Six and allows for conclusions to be drawn on the nature and extent of collaborations between industry and universities, with particular emphasis on the three South Australian universities.

The chapter is organised into a number of sections: Section 7.2 outlines the structure and reporting of the case studies; Section 7.3 contains the relevant secondary data from ARC participation and CRC program, and Section 7.4 contains the university case study.

7.2 Case Study Structure

In organising the case study, the secondary data was analysed before analysis of the primary data obtained from the questionnaire. It allows the key questions relating to university-industry links to be answered and the three South Australian universities to be compared. A question and answer reporting format (Yin, 1994) was used to organise the case study. This format allows the same question to be addressed by different university participants to allow for critical questions to be answered in a concise manner.

The study approach is based on the framework described in Chapter Five. The study areas chosen in this research were faculties and departments at the three local South Australian universities being Flinders University, the University of Adelaide and the University of South Australia. The framework organises the information obtained from the secondary data and questionnaire to reflect the views of academics at the universities on the issue of industry-university collaborations. As the University of South Australia did not participate in the survey, conclusions about their industry links can only be inferred from analysis of the secondary data.

7.2.1 Questions

As stated in Chapter One, there exists a major question of the nature of university-industry links for differently aligned universities. This question is supplemented by more minor questions. Answers to the following questions were required from each of the universities:

- what are the levels of links the university has with industry?
- what are the locations of these industry partners?
- in what industry classification do most of the university-industry collaborations occur?
- what are the views of academics and researchers on collaborating with industry?

- do academics benefit from working with industry?
- how can the level of university-industry collaborations be improved?

Each question addresses a particular component of university-industry links noted in previous chapters. Most of the data used to answer these questions was obtained from the academics who participated in the questionnaire. The answers from the questions will provide an assessment of the nature and extent of links that South Australian universities have with industry and whether these differ between universities.

7.3 Secondary Data

All the secondary data collected was of a quantitative nature, enabling a comparison of the similarities and differences between the three universities on the subject of university-industry links. The ARC Linkage data was obtained through the official ARC web site (ARC, 2006), while the CRC program data was obtained through their official web site (CRC, 2006). The ARC Linkage data analysed is for linkages from 2001 to 2006, while the analysed CRC program data was obtained from the 2006 CRC directory. These official websites are kept current with any new funding outcomes added to the obtainable database. Both the ARC and CRC are statutory authorities within the Australian Governments Innovation, Industry, Science and Research portfolio.

There are other mechanisms and programs for universities to collaborate with industry and to obtain research funding including private collaborations between industry and university, and the NHMRC grants scheme. However the CRC program and ARC Linkage data was selected for use due to the simplicity and ease of obtaining and analysing the relevant data.

Both sets of secondary data were analysed using two sequential processes. The first analysis investigated the overall characteristics of the CRC program and ARC Linkage projects to provide an insight into the number of industry and government partners involved in the CRC program and ARC Linkage projects and the levels of funding they contribute. This analysis was performed to enable determination of the success of different university groupings in these programs and the strengths of different research fields. The final analysis involved a comparison between the three South Australian universities with respect to their success levels, the nature of their industry partners and the respective research areas they are strong in. This analysis was performed to enable a determination of whether the universities positions within the CRC program and ARC linkages are dependent on their different characteristics such as mission goals, history and pedigree.

7.3.1 Cooperative Research Centre

The CRC program was developed, and is funded, by the Australian Federal Government. The program aims to maximise the benefits of collaboration between businesses and university researchers by enhancing the processes of commercialisation, technology utilisation and transfer. A CRC receives funding of between $20-40 million over a seven year period. Each CRC generally consists of core participants, (which are universities), government bodies and partners from the industry/private sector.

Data analysis was conducted on 71 CRCs (Appendix E), categorised into six important industry sectors:

- manufacturing technology
- information and communication technology
- mining and energy
- agriculture and rural based manufacturing
- environment
- medical science and technology

Key statistics for these sectors determined from the CRC data are shown in Table 7.1.

Table 7.1: Key Statistics for each CRC sector

CRC Sector	CRCs	Post Graduates	Full Time Researchers
Manufacturing Technology	12	403	546
Information and Communication Technology	9	400	428
Mining and Energy	8	284	416
Agriculture and Rural Based Manufacturing	16	543	1006
Environment	17	767	980
Medical Science and Technology	9	260	453
Total	71	2657	3829

Source: CRC Directory, 2006

These statistics reveal that the CRC program is delivering a key and critical benefit for industry in enhancing skill development and knowledge through the development of 2657 industry-ready postgraduate students. The table also reveals that for all the sectors there are always more full time researchers than postgraduates, which allows for the retainment of knowledge when postgraduates leave the program.

7.3.1.1 Funding and Partners

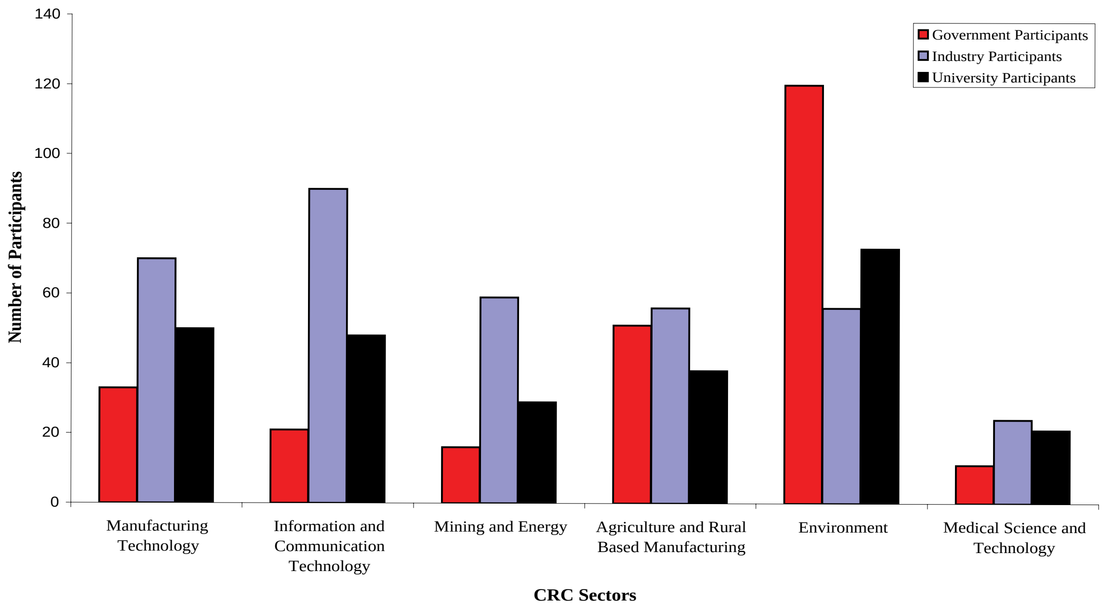
Since the CRC program commenced in 1991, funding parties have committed cash and in-kind contributions totalling more than $12.3 billion. This amount of funding includes $3 billion from universities, $3 billion from the CRC program, $2.5 billion from industry and $1.2 billion from the CSIRO and government bodies.

Analysis of funding and program partners for the CRCs revealed that there are more industry partners than government partners and the funding received from the program itself is less than the funding received from the universities, government participants and industry participants.

A government partner for this analysis was defined as 'a Federal, State or Local government body and Commonwealth research institutions.' This definition of a government partner will also be used in the ARC Linkage and questionnaire analysis. It is usually the case that the same university, industry and government participants are involved in more than one CRC at a time in each of the sectors.

Five out of the six CRC sectors have more industry participants than government participants, with only the environment sector having less. This is seen in Figure 7.1, which shows the number of government, industry and university participants for each CRC sector.

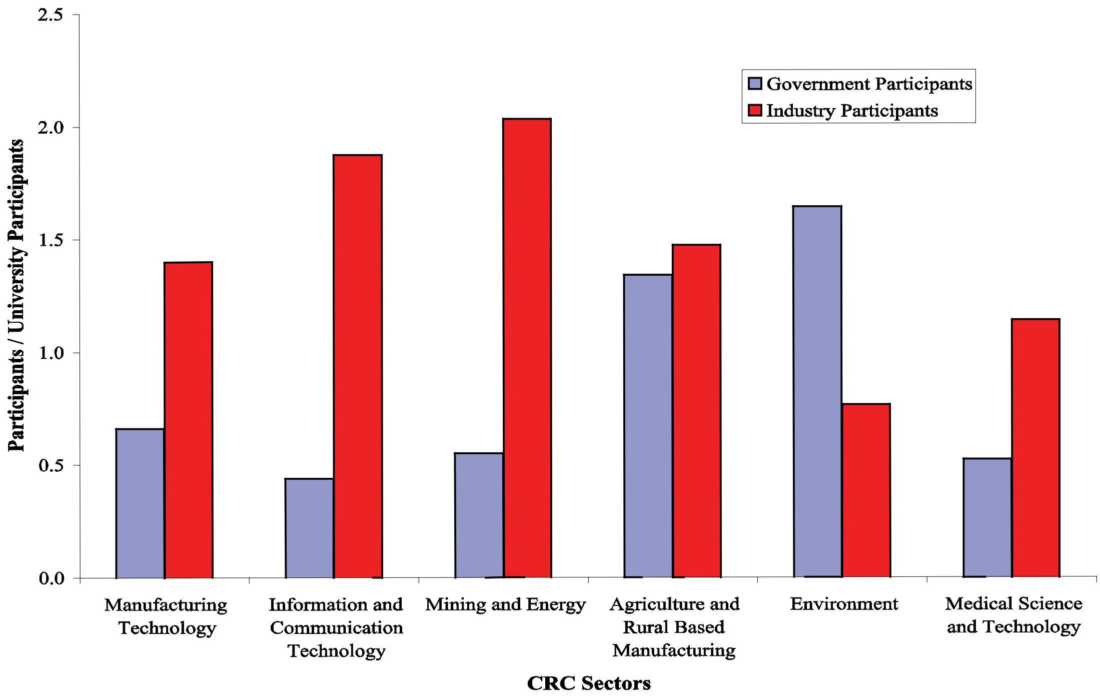
Figure 7.1: Number of core participants for each CRC sector



Source: CRC Directory, 2006

An easier way to compare the number of core participants is to examine the ratios between government, industry and university participants as seen in Figure 7.2 and Table 7.2. By allowing the university participants to equal one and normalising the other participants to this value, the resulting ratio reveals that that the four high technology sectors have more than twice the amount of industry participants as government participants. This maybe due to the industry participants being able to access technology and knowledge by participating in the CRC; internal R&D may not give rise to the same quality and level of information.

Figure 7.2: Normalised core participants for each CRC sector



Source: CRC Directory, 2006.

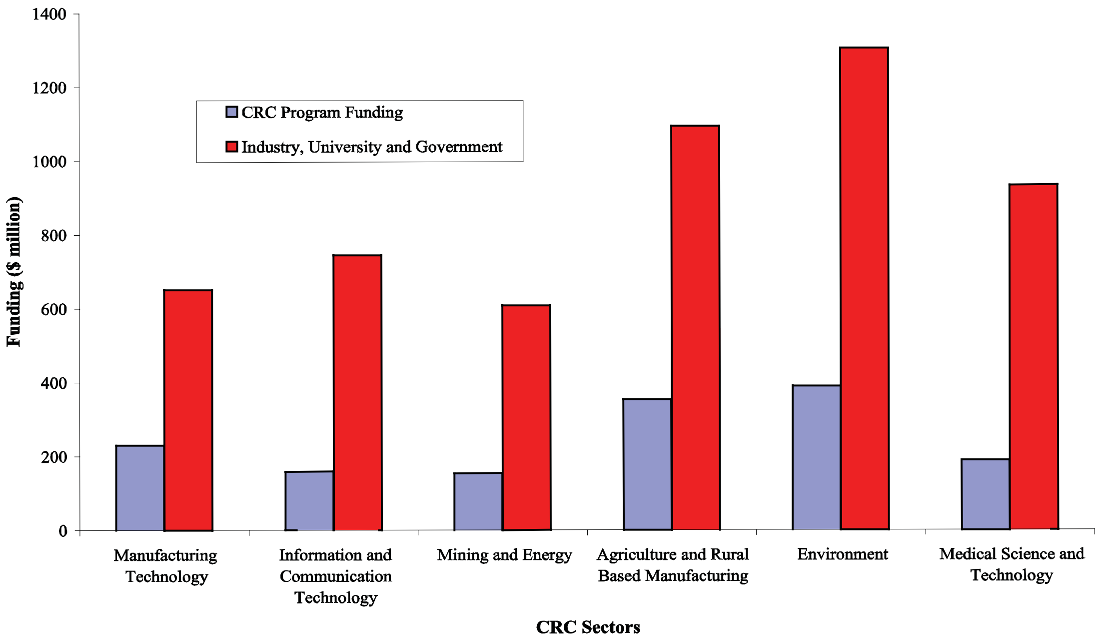
Table 7.2: Number of Industry Partners for every Government Partner

CRC Sector	Number of Industry Partners for each Government Partner
Manufacturing Technology	2.1
Information and Communication Technology	4.3
Mining and Energy	3.7
Agriculture and Rural-based Manufacturing	1.1
Environment	0.5
Medical Science and Technology	2.2

Source: CRC Directory, 2006.

The two low technology sectors of Agriculture and Rural-based Manufacturing, and Environment have a lower number of industry partners for each government partner than the other four high technology sectors as most of the participants in these sectors are the federal and state government primary resources and environment departments.

Figure 7.3: Different types of funding for each CRC sector



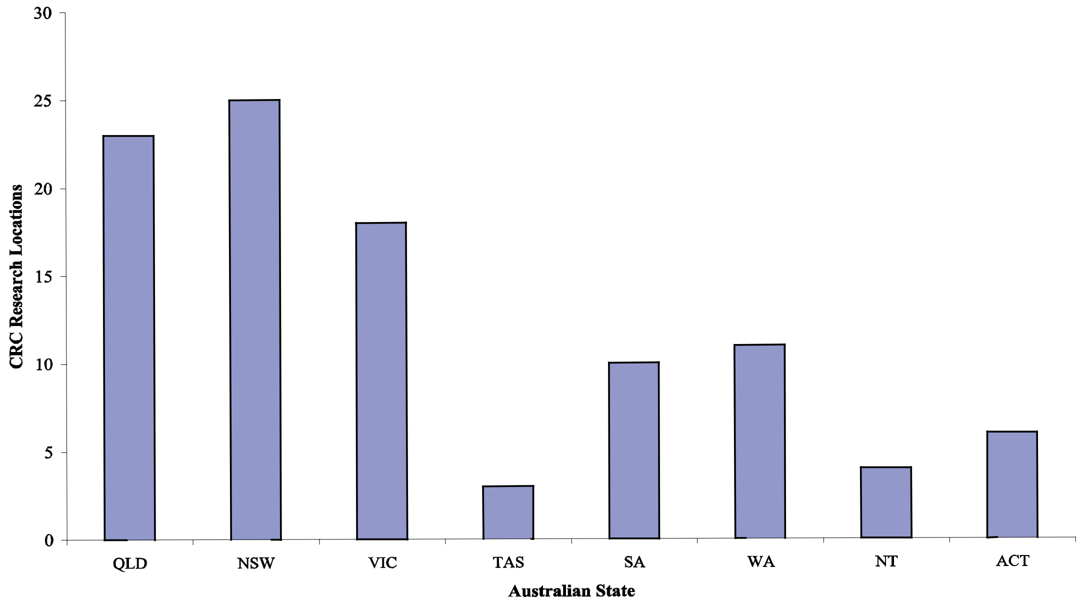
Source: CRC Directory, 2006.

As seen in Figure 7.3 the majority of funding for the CRCs comes from the industry, government and university partners. It was not possible to dissect these further, but from Figure 7.2 and Table 7.2 it would be expected that due to the greater number of industry partners in each sector, the majority of funding would come from these industry partners.

7.3.1.2 Research Locations

Each CRC undertakes research at various locations around Australia. By basing the CRC at various locations, the CRC is able to develop and commercialise technology in different regions and allow the relevant industries within those regions to access the skilled postgraduates. Most of the research locations are found on the east coast of Australia with nearly 66% being located in Victoria, N.S.W. and Queensland as shown in Figure 7.4.

Figure 7.4: Number of CRC locations across Australia



Source: CRC Directory, 2006.

This location majority is because most of Australia’s universities and industries are located on the east coast of Australia, while South Australia and Western Australia have 10% each which is impressive for the size of their populations and the number of universities and businesses located in each of these states.

7.3.1.3 University Involvement

When investigating university groupings in the CRC program, Table 7.3 shows the numbers and percentages of CRCs involving at least one member university from each grouping. This table reveals that the Go8 universities are involved in 53 CRCs, which is 75% of the total number of CRCs investigated. The next major university involvement is the ATN (42%) followed by the IRU then NGU groupings.

Table 7.3: Number of CRCs at least one university from a grouping is involved in

	Group of 8	ATN	IRU	NGU
Number	53	30	23	12
Percentage	75	42	32	17

Source: CRC Directory, 2006.

It can be seen in Table 7.4 that the University of Adelaide is involved in 15 CRCs, while the University of South Australia is involved in 10 and Flinders University is involved in 3. The table also dissects the number of CRCs each university is involved in by CRC sector and the number of involvements in each sector. The University of Adelaide is involved in 5 of the 6 sectors while Flinders University and the University of South Australia are involved in 3 sectors.

Table 7.4: CRC involvement for the South Australian Universities

	Flinders University	University of Adelaide	University of South Australia
Number	3	15	10
Breakdown of Total CRC Involvement	Information and Communication Technology (1) Agriculture and Rural Based Manufacturing (1) Medical Sciences and Technology (1)	Manufacturing Technology (1) Information and Communication Technology (2) Mining and Energy (3) Agriculture and Rural Based Manufacturing (5) Environment (4)	Manufacturing Technology (3) Information and Communication Technology (3) Environment (4)

Source: CRC Directory, 2006.

7.4.1 ARC Linkage Projects

The linkage scheme run by the ARC supports collaborative research and development projects between universities and other organisations such as industry and government departments (ARC, 2008). Funding for these projects must involve a collaborating organisation outside the higher education sector and the contribution whether it be cash or in kind, from these organisations must be equal to, or greater than, the ARC funding.

The Linkage projects aim to:

- encourage and develop long term research alliances between universities and industry.
- apply specific knowledge to problems to obtain national economic and social benefits.
- provide industry orientated research to prepare postgraduate students.
- produce a national source of expert and experienced researchers to meet the requirements of Australian industry.

Data analysis was conducted on all ARC Linkage projects that commenced between the years of 2002 and 2007. This analysis was conducted in the two sequential steps described in Section 7.3.

7.4.1.1 Projects, Funding and Partners

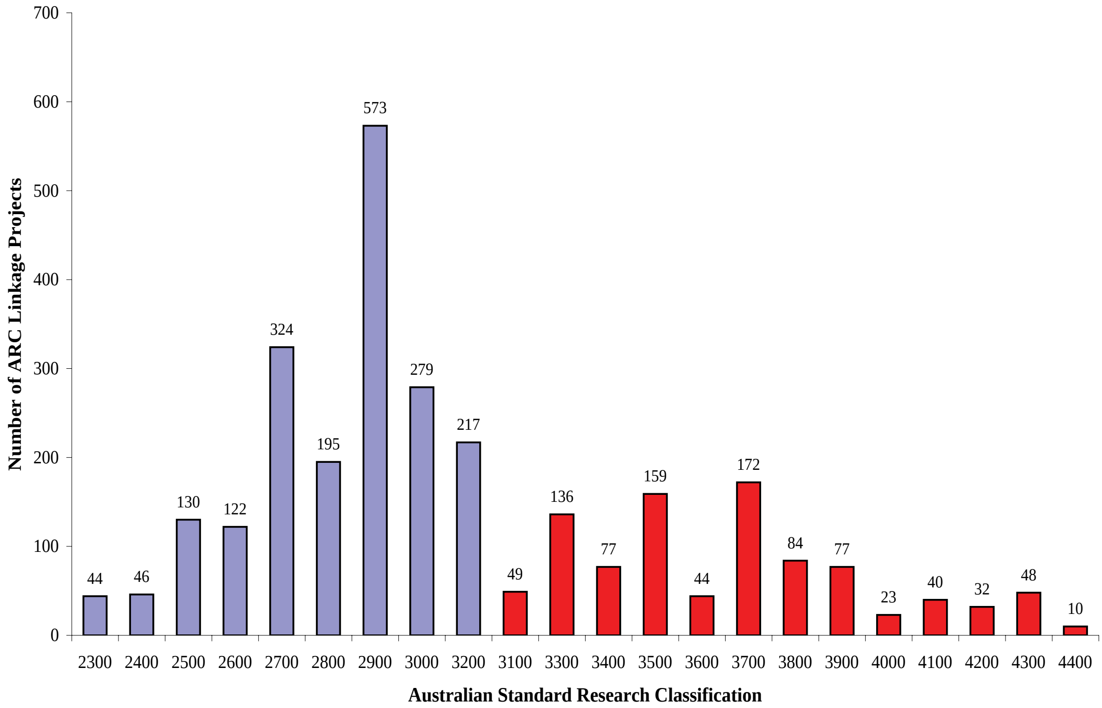
Nearly 2900 ARC Linkage projects have commenced in the years 2002 to 2007 from over 6200 applications. This equates to a success rate of nearly 47% over that time period. Table 7.5 shows the number of applications, number of projects awarded and success rate for the corresponding years from 2002 to 2007. The success rate for the years 2005 and beyond has fallen below 50%.

Table 7.5: Success Rate of ARC applications for 2002 to 2007

	Number of Applications	Number of Projects	Success Rate
2002	911	470	52%
2003	1174	587	50%
2004	1048	532	51%
2005	1048	488	47%
2006	1106	400	36%
2007	958	425	45%

The Australian Standard Research Classification divides research fields into different categories that are described in Appendix F. These categories have been divided into two main sections, being science/technology and social sciences. The majority of ARC Linkage projects are in the science area with nearly 20% of the projects for that time period being in the engineering research field (see Figure 7.5). This reveals that industry partners for ARC linkage projects are more likely to be science or engineering businesses than government departments or social science businesses.

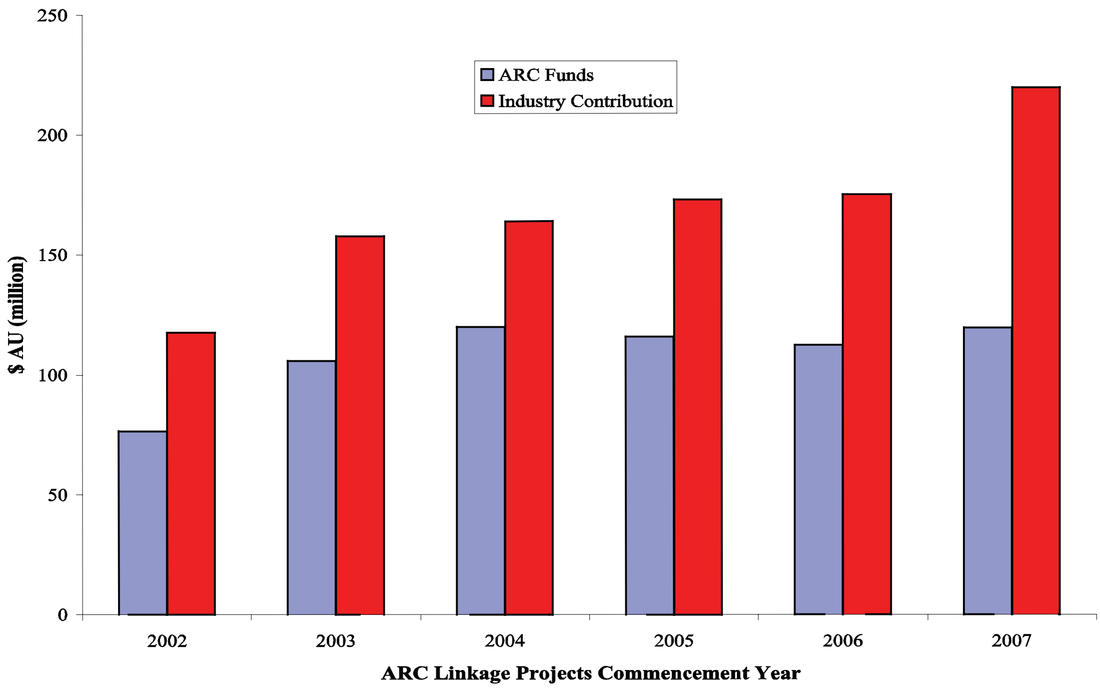
Figure 7.5: Number of ARC linkage projects by research field for 2002 to 2007



Note: Blue indicates science/technology research fields and red indicates social science research fields

ARC Linkage projects for the years 2002 to 2007 have received funding of over $1.65 billion with nearly 60% of that coming from the industry partners. Figure 7.6 shows that over this period, the ARC funding has remained fairly consistent while the funding from industry has risen by around 5 percent each year, with an increase of nearly 25% from 2006 to 2007. This reveals that industry see the potential for collaborating with universities to either solve a specific problem, conduct research or develop and enhance their knowledge base as being of significant value. For every dollar that the ARC contributes, industry contributes over 1.5 dollars.

Figure 7.6: Comparison of ARC and industry funding for ARC linkage projects for 2002 to 2007



The number of ARC Linkage project partners between 2002 and 2007 has remained fairly consistent with the lowest being 736 partners in 2002 and the highest being 939 partners in 2004. These partners have been classified as, industry (private businesses-state, interstate, or national), or government (Federal, State or Local) or international (with or without operations in Australia). The overall classification and definitions of each partner type has been discussed in Chapter 5.

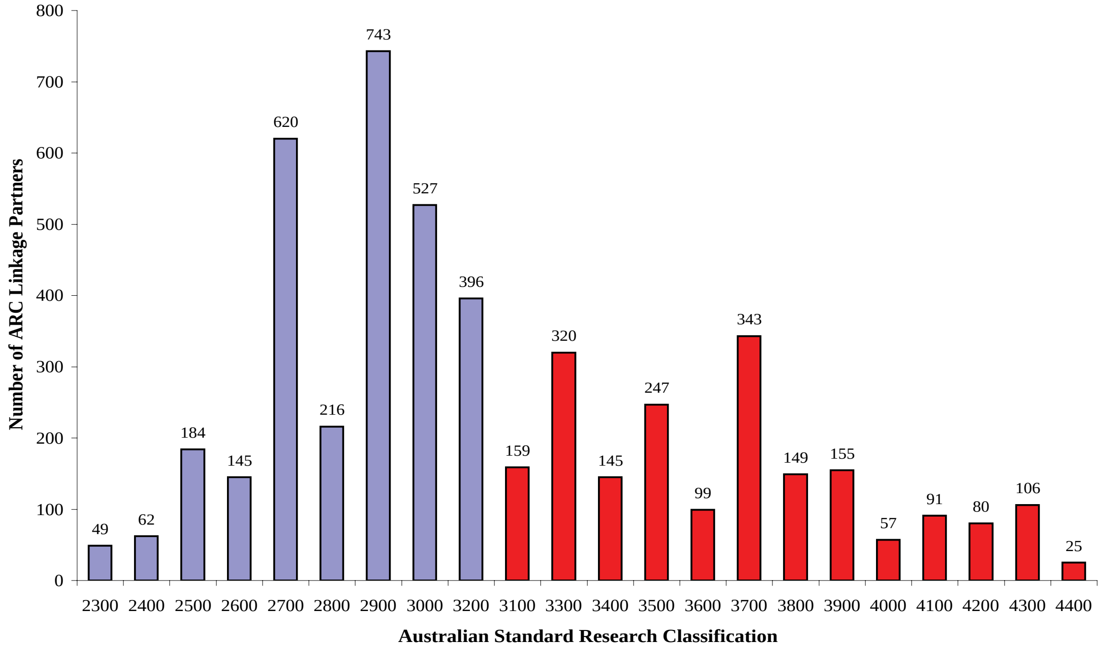
Table 7.6 shows that for each year, over 50% of the partners are industrial enterprises, with government partners accounting for around 37-40% and international partners only 9-10%. Even though the number of partners changes from year to year, the composition of partners stays relatively the same.

Table 7.6: Percentage of different ARC linkage partners for 2002 to 2007

	Total Number of Partners	Industry Partners %	Government Partners %	International Partners %
2002	736	53	37.5	9.5
2003	933	53	37.5	9.5
2004	939	49	41	10
2005	895	51	40	9
2006	764	50	41.5	8.5
2007	861	53	37	10

Like the total number of projects, a breakdown of the partners for this time period shows that the majority of partners are involved in projects in science and technology fields as seen in Figure 7.7. This is expected as most Linkage projects are in this area and so one would conceive this area would possess the majority of industry partners.

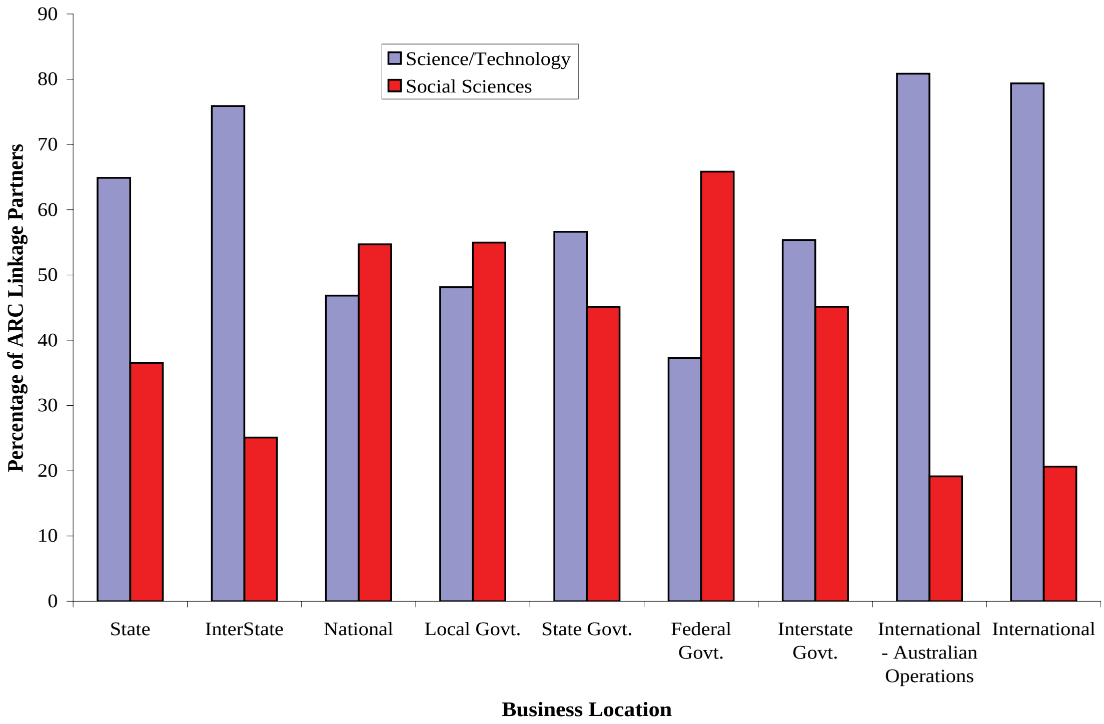
Figure 7.7: Number of ARC linkage partners by research field for 2002 to 2007



Note: Blue indicates science/technology research fields and red indicates social science research fields

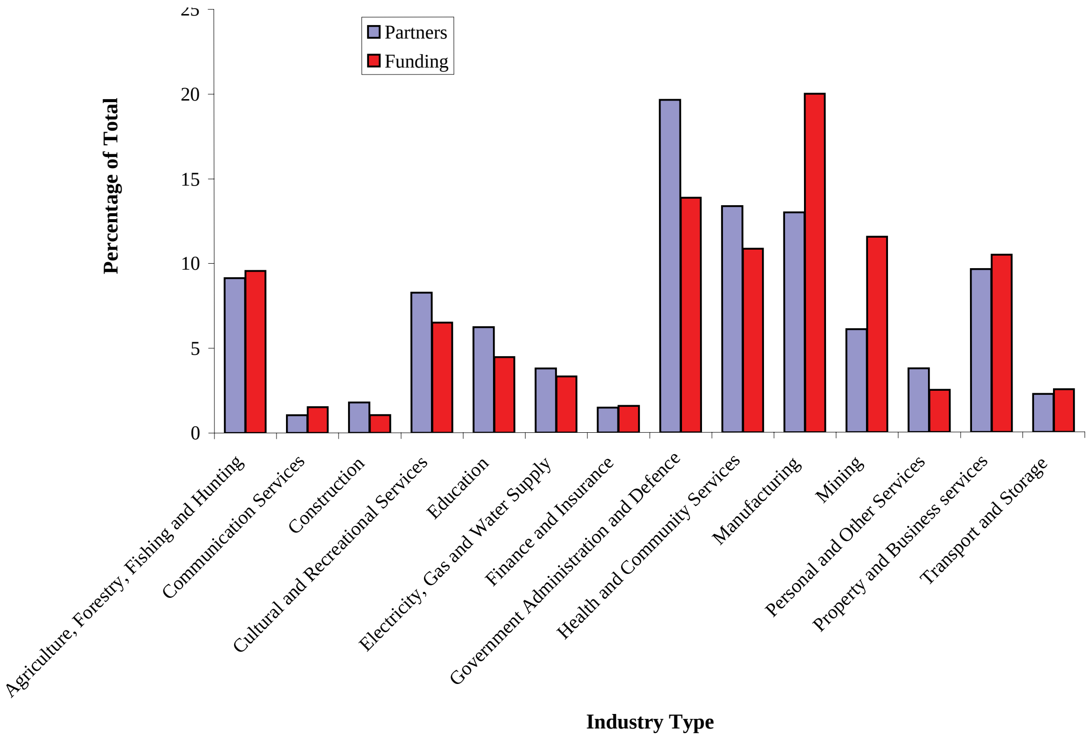
Figure 7.8 shows the percentage of ARC linkage partners for the science/technology and social science fields and their relevant classification. The data indicates that the private industrial and international businesses are the main partners in science and technology projects, while the social science projects generally contain government department partners. This breakdown of industry partners will allow a determination of the overall types of partners and projects that each of the universities collaborates with, and the types of projects each university is involved in.

Figure 7.8: Percentage of Partners by Industry type for 2002 to 2007



If the types of businesses are investigated, (Figure 7.9) it is evident that the manufacturing sector contributes around 13% of project partners but nearly 20% of project funding and mining sector contributes 6% of project partners and nearly 14% of project funding. These sectors may invest more in university links due to their understanding of the roles knowledge, innovation and research play in the new knowledge economy. This is in contrast with the government administration and defence sector, which has 20% of project partners but only provides 14 % of project funding. This reduced amount of funding could be due to defence and some of the departments doing their own in house research through CSIRO and the DSTO.

Figure 7.9: Percentage of Partners and Funding of ARC Linkage Projects for different Industry Sectors for 2002 to 2007



Analysis of the data for the ARC linkage projects for 2002 to 2007 overall reveals the following characteristics:

- the number of applications and projects remains fairly consistent, with an overall success rate of around 47-50%.
- the majority of Linkage projects and partners are in the science and technology fields.
- industry partners provide nearly 60% of the funding to the projects.
- industry funding for the projects has increased every year even though the number of partners has remained consistent.
- the linkage partners are usually around 50% private businesses, 40% government departments and 10% international businesses.
- government departments are usually involved in social science projects while private businesses are involved in science and technology projects.
- manufacturing sector and mining sector provide greater percentage of funding than partners, but this trend is reversed for government departments.

These characteristics indicate that industry partners are willing to invest in ARC Linkage projects, which shows that they view university-industry collaborations as an important means for gaining solutions to problems and for enhancing their research and knowledge base for economic growth in today's knowledge economy.

7.4.1.2 University Groupings

The groupings of universities in Australia have been previously described and these groupings are essentially composed of universities that share similar visions, research and teaching goals. It would be expected that due to these goals being different from grouping to grouping, that grouping participation this would have an effect on the nature and levels of university-industry collaborations. This section will analyse the ARC Linkage project data for 2002 to 2007, specifically investigating the five different university groupings and the three South Australian universities within each of their respective groupings.

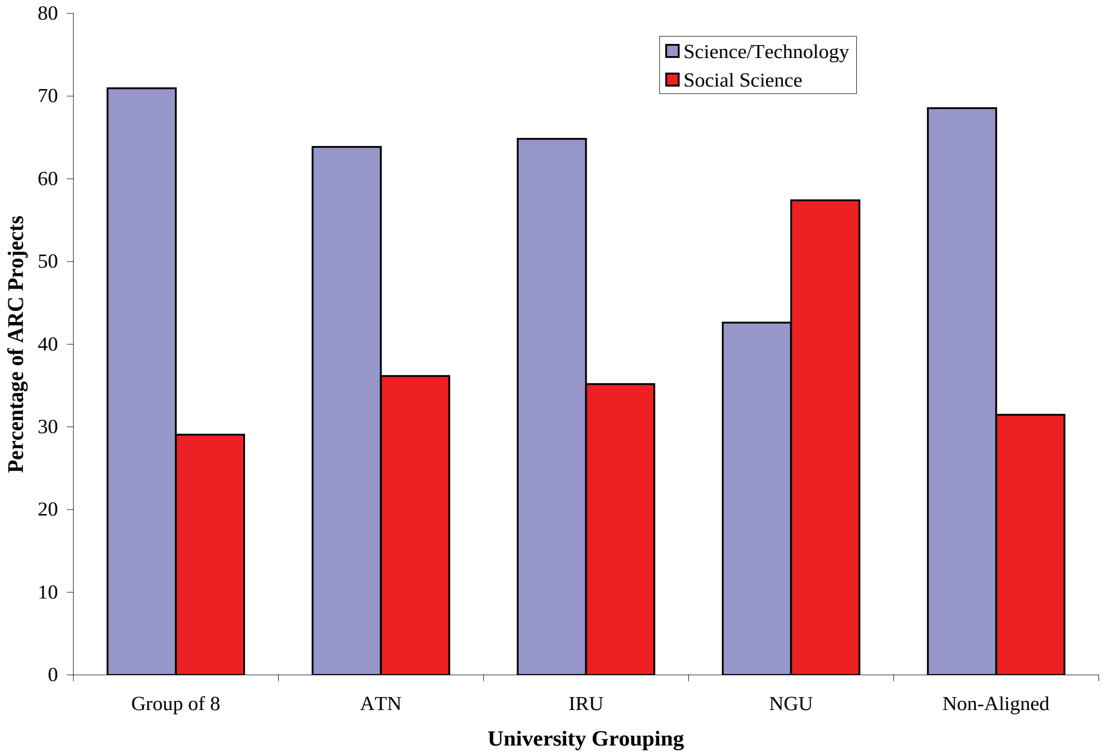
Table 7.7: Percentages of different ARC linkage project factors for the five university groupings, 2002 to 2007

	Projects	Success Rate	ARC Funds	Industry Contribution
IRU	12.16	46.28	11.22	11.01
Group of 8	50.17	52.76	56.77	59.23
ATN	17.13	43.42	16.33	15.80
NGU	6.75	30.44	4.62	4.36
Non-affiliated	13.78	40.05	11.06	9.60

Table 7.7 indicates that the ARC Linkage program is dominated by the Go8 universities. They account for over 50% of projects, ARC funds and industry contributions and have a success rate of greater than 50% for that time period compared to the average success rate of 46.5%. This is due to the fact that this grouping represents Australia's leading universities, which have the funds, equipment and knowledge to attract industry partners. The ATN is next, accounting for around 15-17% of the above factors and this would be mainly due to the member

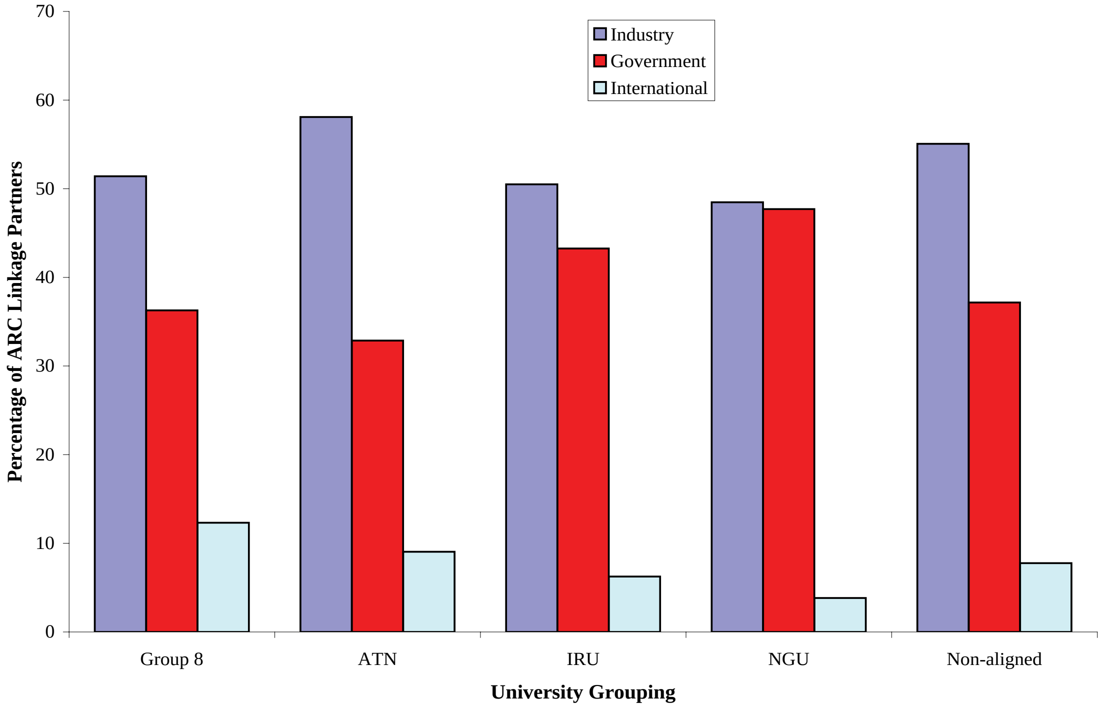
universities having a history of working with industry on applied research projects. The IRU Australia grouping accounts for nearly 12% of the above factors and this is mainly due to their ethos of developing innovative approaches to research and community involvement.

Figure 7.10: Percentage of science/technology and social science ARC projects for the five university groupings, 2002-2007



ARC linkage projects for each university groupings except for NGU in the science and technology fields are greater than 50%, with the Go8 at over 70% (Figure 7.10). This is in accordance with Figure 7.5 which showed that the majority of projects are in the science and technology fields. Figure 7.11 shows that industry partners are the majority partner type for Linkage projects, for all university grouping except NGU. The ATN has nearly 60% of partners comprised of industry and only 30% government while IRU has 50% industry and 44% government. The Go8 is the only grouping that has over 10% international partners. It is expected that most of the partners involved in university-industry links would be the industry type, as they constitute private businesses that are mainly involved in the science and technology fields.

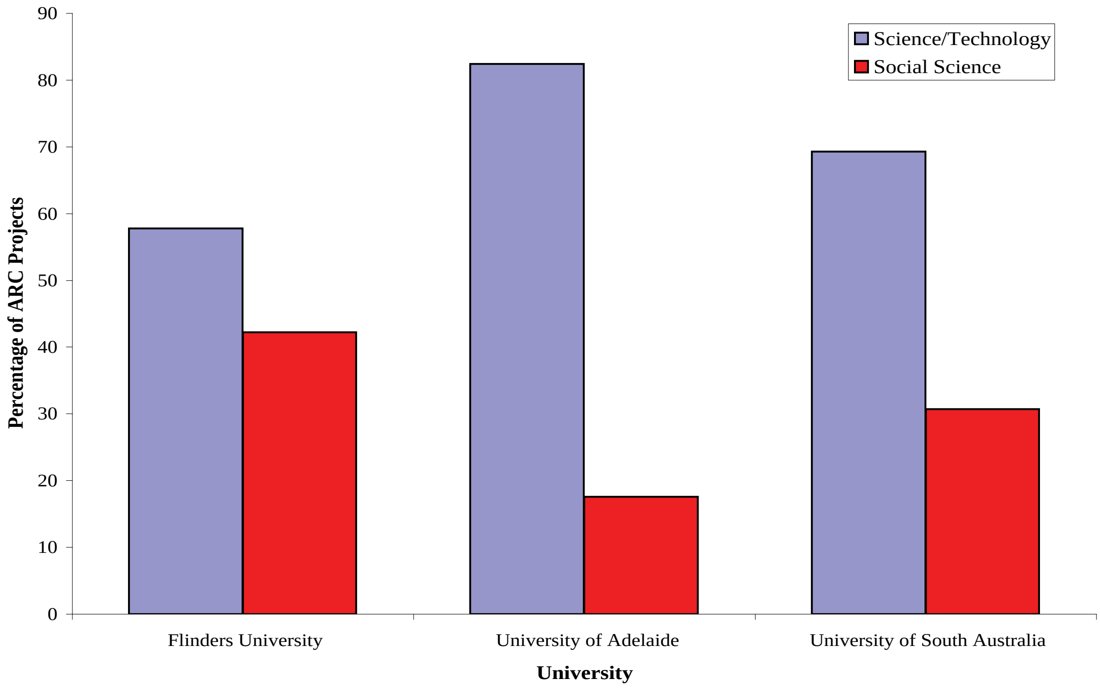
Figure 7.11: Percentage of partners by industry type for the five university groupings, 2002-2007



7.4.1.3 South Australian Universities

As mentioned before the three South Australian universities are aligned with different university groupings. Flinders University is aligned with the IRU, the University of Adelaide is aligned with the Go8 and the University of South Australia are aligned the ATN. By investigating ARC Linkage projects for each of these universities it can be determined if the three South Australian universities follow the trends of the overall ARC analysis and the characteristics of their respective groupings.

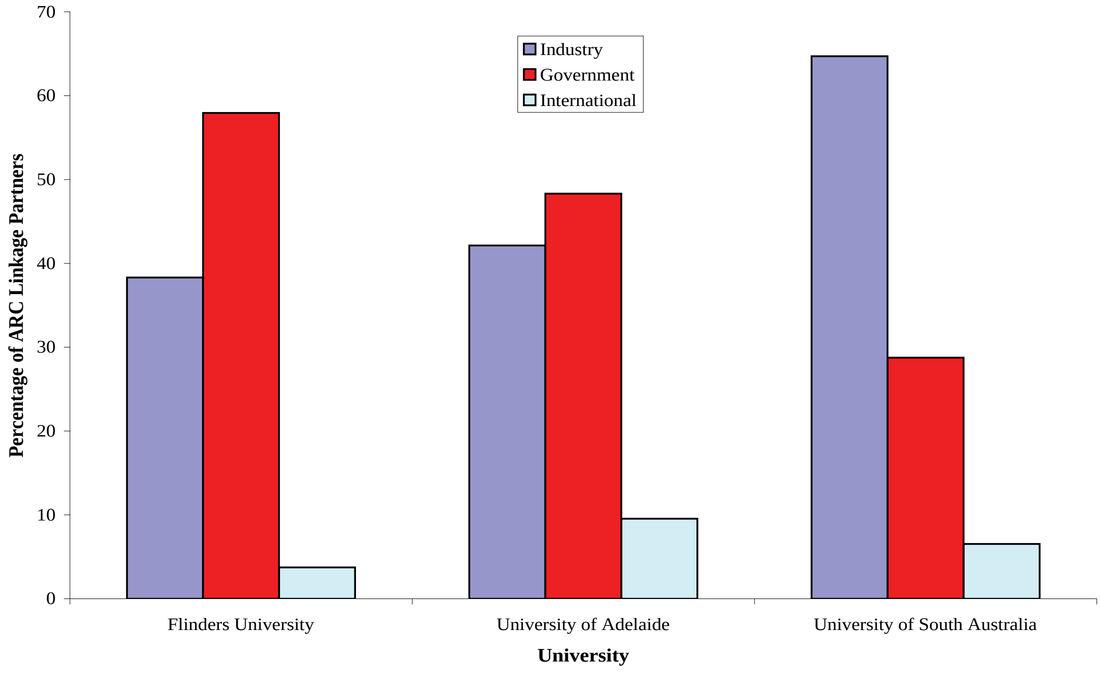
Figure 7.12: Percentage of science/technology and social science ARC Linkage projects for the three South Australian universities, 2002-2007



In comparing the universities, Figure 7.12 shows that more than 50% of ARC Linkage projects at the three South Australian universities are within the science/technology field. Over 80% of ARC Linkage projects at the University of Adelaide are science/technology projects, followed by 70% at the University of South Australia. Flinders University has 58% science/technology projects, which is less than the percentage for the IRU. The University of Adelaide has nearly 10% more science/technology projects than the Go8 and the University of South Australia has 5% more science/technology projects than the ATN. This implies that the science and technology departments at the University of Adelaide and University of South Australia market their capabilities to industry better than Flinders University.

As all three universities have more science/technology projects than social science projects, it is expected that they would all have more industry partners than government or international partners. Figure 7.13 shows that this is correct for the University of South Australia, but not for Flinders University and the University of Adelaide.

Figure 7.13: Percentage of partners by industry type for the three South Australian universities, 2002-2007



Flinders University partners are 58% government, 38% industry and 4% international while the reverse trend is observed for the University of South Australia, which has 66% industry and only 28% government partners. This distribution of partners for Flinders University is the opposite of the distribution for its IRU grouping, while the University of South Australia distribution is the same as the ATN. The University of Adelaide has 48% government and 42% industry partners, which is different and opposite to the Go8 trend. This indicates that Flinders University is more inclined to align its research with government departments as opposed to the University of South Australia, which is staggered towards private businesses. It can be considered that the University of Adelaide's research aligns with both private businesses and government departments. This finding, together with the finding that industry sectors provide more funding than government departments (Figure 7.9) implies that Flinders University is receiving considerable less funding for its ARC Linkage projects than the University of South Australia.

It is clear that investigating just the CRC and ARC Linkage programs as a determination of the nature and levels of university-industry links is an over-simplification of university-industry involvement, as other forms of links such as NHMRC and private projects haven't been considered. However, it is still considered reliable and valid that this data analysis provides a good basis to draw conclusions about the university-industry links for the different university groupings and the three South Australian universities.

7.4.2 Secondary Data Summary

The CRC and ARC Linkage programs have been introduced by the Federal Government to increase links between universities and industry. It is clear from the above data analysis that both of these programs are dominated by the Go8 universities. They are involved in 75% of CRCs, and over 50% of ARC Linkage projects and funding has been allocated to these universities. In the CRC program most of the industry partners are in the science, manufacturing and mining sectors, with most CRC sites being located on the east coast of Australia.

For the ARC Linkage program over 50% of ARC Linkage projects and partners are in the science/technology fields. Funding from the ARC for these Linkage projects has been consistent while for the same time period industry funding has increased by 5% each year and now accounts for nearly 60% of total funding for the projects. Private businesses account for over 50% of industry partners and they are usually in the science/technology fields while the social science field is mainly comprised of government industry partners. All three South Australian universities have greater 50% of their projects in the science and technology field with the University of Adelaide and the University of South Australia at 80% and 70% respectively.

In relation to the nature of Linkage partners the majority of partners at the University of South Australia are private businesses (63%), while for Flinders University (58%) and the University of Adelaide (47%) it is government departments. The analysis of data from the CRC program and ARC Linkage program has shown similar trends for the university groupings for the different industry types and that the University of Adelaide and the University of South Australia are very active in the programs as opposed to Flinders University.

The data also shows that the University of South Australia links more with private businesses than Flinders University and the University of Adelaide.

7.3 Case Study

Analysis of the secondary data has formed a basis for an understanding of the case study on university-industry links. The primary data differs from the secondary in that it is both quantitative and qualitative in nature and investigates the principles and opinions of academics on university-industry links.

It also investigates the nature of links, type of industry partners (similar to the secondary data) and the benefits obtained form these links. The primary data will also provide possible solutions to increasing the level of university-industry links and whether academics that have industry collaborations have more resources and differing research practices than non-industry linked academics.

7.3.1 Classification of University-Industry Links

The questionnaire distributed to university academics asked questions relating to academics profile, whether they have had industry links, reasons for or against these links and possible ways to improve industry links. Respondents were asked to indicate their level of agreement with statements through a five point Likert scale. In the answering these questions, respondents from the questionnaire represent varying levels of university academics. The response rates for the questionnaire from Flinders University and the University of Adelaide were 29.55% and 20% respectively. These response rates were lower than hoped for, but as Harman (1999) notes, this may be due to the large work loads of many academics and the number of questionnaires they are exposed to.

7.3.2 Academic Values

The first section of the case study involved asking respondents for their perspectives on academic values and their field of research. Respondents were asked to nominate from a list of answers the appropriate answer they best though fit their situation.

The first column of each table represents either the mean scores or percentage for Flinders University respondents, while the second column is the mean scores or percentage for the University of Adelaide respondents. The final column is the probability that the difference between the means or the percentages is a chance event. The method for describing the results of the Likert scale is to compare the absolute value for each university, and identify that a mean score greater than 2.5 indicates that the factor is of some importance and that a mean score below 2.5 suggests that the factor is of little importance. The analysis of the data for mean scores also considered the differences between the universities using analysis of variance (ANOVA), which allowed for determination if these differences were significant and at what level of significance (*p*-value).

The method for describing the percentage of respondents is by comparing the percentage of respondents to each factor and recognising that the higher the percentage of a factor, the more the respondents feels that factor is important. Analysis of the data for the percentage of respondents takes into account differences between the Flinders University and the University of Adelaide using a comparison of binomial proportions in two different populations' statistical method. This allowed for a *p*-value to be calculated, which is used to determine if the difference was significant and if so what level of significance. Description of the statistical methods used in this section is described in Chapter Six.

Table 7.8: Importance of factors when choosing field of research

Factors	Flinders University#	University of Adelaide#	*p*-value
Personal Interest	4.28	4.35	0.717
Likelihood of commercial application of results	2.30	2.34	0.843
Availability of funding from an industry source	2.58	2.88	0.109
Availability of funding from your own institution	3.10	2.90	0.276
Availability of funding from another source	3.14	3.13	0.963

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor

The data represented in Table 7.8 shows that four of the five factors have scores above 2.5, suggesting that these factors are important for academics when choosing their field of research. There is no significant difference between the universities for each of the factors and both universities have personal interest as the most important factor for academics deciding on their research field. The likelihood for commercial application of results was the only factor that was deemed by academics not to be important. This implies that most academics don't choose their field of research on the likelihood of producing commercial products or outcomes.

With respect to academic values, respondents were asked to indicate their agreement with some statements towards academic values. Table 7.9 shows the percentage of respondents who agreed with statements about academic values. A resounding amount of respondents (over 90%) at both universities believe that research results should be shared throughout the academic community. Over 50% of respondents at both universities agreed that an academic must be an active researcher to be a good lecturer or teacher.

Table 7.9: Percentage of respondents who indicated they agreed with the statements about academic values

Academic Values	Flinders University %	University of Adelaide %	*p*-value
University research should be investigator driven and not target orientated	36.8	58.3	0.049**
Fundamental research is more important than applied research in an university environment	21.2	41.7	0.037**
In order to be good teacher, an academic must be active in research	61.6	58.3	0.764
Research results should be shared througout the academic community	92.8	95.8	0.586

Note: Flinders University n=133; University of Adelaide n=80
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

There was a significant difference between the universities on the first two statements regarding applied research and fundamental research. Only 37% of respondents at Flinders University agreed that research should be investigator driven as opposed to nearly 60% of respondents from the University of Adelaide. It seems that at both universities, respondents believe applied research is just as important as fundamental research, with only 21% of respondents from Flinders University agreeing with the statement. This data indicates that respondents hold traditional university values regarding teaching and fundamental research, but at the same time are open to the idea of doing applied research with industry. These results are similar to those of Harman (1999), who determined that academic research results should be disseminated among the academic community and that fundamental and applied research are important in a university environment.

Respondents were then asked their agreement on statements regarding links with industry. Table 7.10 shows the percentage of respondents who agreed on statements concerning industry links. Less than 20% of respondents from both universities believe industry links pose threats to traditional university values. Only 27.7% of respondents from Flinders University believe that the ARC Linkage program has been a success, which is significantly different to respondents (43.5%) from the University of Adelaide.

Table 7.10: Percentage of respondents who indicated they agreed with the statements about industry links

Statements about industry links	Flinders University %	University of Adelaide %	*p*-value
It is exciting working with industry	42.1	56.3	0.07*
I like consultancy work because of the additional earnings	38.5	49.2	0.173
The ARC linkage projects have been a success	27.7	43.5	0.039**
Industry links pose threats to traditional values	17.0	19.4	0.698

Note: Flinders University n=133; University of Adelaide n=80
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

The data shows that significantly more University of Adelaide than Flinders University respondents believe that it is exciting working with industry. Surprisingly, less than half of respondents from both universities agreed they like consultancy work because of the additional earnings. This number was expected to be larger for both universities as increased funds is one of the major motivations and benefits for working with industry.

This section reveals that respondents from both universities choose their field of research based on personal interest and believe that industry links don't pose threats. Respondents from both universities view applied research as being just as important as fundamental research, and that research outcomes and results should be shared among the wider academic community, even though this would violate possible confidentiality agreements in industry collaborations

7.3.3 Academics with industry links

The following section investigates different characteristics of university-industry links for Flinders University and the University of Adelaide from the perspective of the collaborating academics. For Flinders University and University of Adelaide, 61% and 54% of respondents respectively had a university-industry link. The section specifically looks at the different types of links, the nature of the collaborating partners, views on why academics collaborate or don't collaborate with industry and how these links could be improved. Key characteristics of university-industry collaboration was determined by asking respondents to nominate the nature of the collaboration, type of collaboration and which partner initiated the collaboration.

Table 7.11 shows that there are no significant differences between the two universities on the nature of collaborative links. For both universities, over 50% of respondents stated that their collaborative links were a combination of formal and informal links. The data also highlights the small percentage of informal links, which implies that both industry and academic partners prefer to have some sort of contractual agreement for their collaboration.

Table 7.11: Nature of collaborative links

Status of links	**Flinders University %**	**University of Adelaide %**	*p*-value
Formal	37.0	39.5	0.785
Informal	6.8	9.3	0.633
Both formal and informal	56.2	51.2	0.601

Note: Flinders University n=81; University of Adelaide n=43

The data for the collaboration initiator shown in Table 7.12 reveals that there are significant differences between both universities. The data indicates that for the University of Adelaide, the majority of collaboration initiation was a combination of the academic and industry partner, while for Flinders University the initiation was consistent for across all three possible collaboration initiators.

Table 7.12: Collaboration initiation

Collaboration Initiation	**Flinders University %**	**University of Adelaide %**	*p*-value
Academic	32.9	18.6	0.097*
Industry Partner	32.9	11.6	0.011**
Combination of academic and industry partner	34.5	69.8	0.000***

Note: Flinders University n=81; University of Adelaide n=43
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level; *** p value of 0.01 or less is a significant difference at a 99% confidence level

Leading on from this, respondents were then asked to nominate from a list the type of formal links they had with industry. The data from Table 7.13 indicates that 40.3% of Flinders University respondents had formal links consisting of a private project while the majority of respondents from the University of Adelaide (58.1%) had consultancies to solve a specific problem. The two different responses are significantly different.

The table also shows that 41.9% of respondents from the University of Adelaide had an ARC Linkage project as opposed to 28.4% of Flinders University respondents. These numbers are supported by the levels of Linkage projects from the secondary data. The high percentage of ARC linkage and formal consultancy links for the University of Adelaide indicates that the university markets its capabilities to specific industry partners.

From the secondary data, one would envisage that a high percentage of academics at the University of South Australia would have a consultancy and/or ARC linkage project as these formal links usually involve a private business in the science/technology field.

Table 7.13: Type of formal links

Formal Links	**Flinders University %**	**University of Adelaide %**	*p*-value
A private project	40.3	34.9	0.568
A consultancy to solve a specific business problem	38.8	58.1	0.047**
Through an ARC linkage project	28.4	41.9	0.144
Business sponsorship of a course	6.0	4.7	0.766
Other	23.9	11.6	0.111

Note: Flinders University n=81; University of Adelaide n=43
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

The respondents who had undertaken a consultancy were asked what the driving force was for doing this consultancy.

Table 7.14 shows that the majority of respondents at both universities stated that opportunity or income was the driving force for doing a consultancy. Nearly 50% of respondents from the University of Adelaide replied that commercialisation or technology development was a driving force which is significantly different than the 27.4% of Flinders University respondents. The majority of links in the 'other' category consisted of CRC involvement for both universities.

Table 7.14: Driving force for undertaking consultancy

Driving Force	Flinders University %	University of Adelaide %	*p*-value
Opportunity (income)	72.8	73.3	0.877
Commercialisation (Technology Development)	27.4	49.1	0.026**
Research (Research Opportunities)	40.2	21.8	0.039**

Note: Flinders University n=81; University of Adelaide n=43
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

Significantly more respondents (40.2%) from Flinders University stated that research opportunities were the driving force for undertaking consultancy compared to respondents from the University of Adelaide (21.8%). This shows that Flinders University respondents regard commercialisation as the least important driving force for undertaking consultancy, while for the University of Adelaide respondents, research opportunities are least important. This may be due to the University of Adelaide having better processes to commercialise the outcomes of university-industry research.

It would be expected that academics at the University of South Australia would have the same order of driving forces as academics at the University of Adelaide as they collaborate on more industry aligned research projects.

Table 7.15: Average length of university-industry projects

Average industry project length	Flinders University %	University of Adelaide %	*p*-value
1 year	23.3	29.3	0.482
2 years	32.9	9.8	0.006***
3 years	28.8	41.5	0.167
4 years	4.1	12.2	0.105
Greater than 4 years	11.0	7.3	0.527

Note: Flinders University n=81; University of Adelaide n=43
*** p-value of 0.01 or less is a significant difference between groups at a 99% confidence level

The next question asked respondents to indicate the average length of their industry project. Table 7.15 shows that for the University of Adelaide, 41.5% of respondents have an average project length of 3 years. Nearly 33% of Flinders University respondents had an average industry project length of 2 years, which is significantly greater than the 9% of academics from the University of Adelaide. The longer projects are likely to be an ARC Linkage project or government grant project, while the shorter one year projects are probably private projects or a specific consultancy.

Table 7.16: Type of research activity that respondents find important

Research Activity	Flinders University %	University of Adelaide %	*p*-value
Industry related research	13.7	9.5	0.510
Academic related research	21.9	21.4	0.951
Combination of academic and industry research	64.4	69.1	0.611

Note: Flinders University n=81; University of Adelaide n=43

It can be seen in Table 7.16 that at both universities, over 60% of academics regard both industry (applied) and academic (fundamental) research as important for their research activities. This implies that these academics are content to do fundamental research as well as still forming industry collaborations. This supports Harman's (1999) and Blumenthal's (1996) findings that academics who work with industry do not forego their university roles in undertaking basic and fundamental research.

Table 7.17: Type and location of industry partners that respondents collaborate with

Industry Partners	Flinders University %	University of Adelaide %	*p*-value
Onkaparinga, Marion, West Torrens, Holdfast Bay or Fleurieu region business	23.1	22.8	0.871
Playford, Enfield, Charles Sturt, Pt. Adelaide Salisbury or Tea Tree Gully region business	21.9	39.5	0.042**
Interstate business	45.0	70.4	0.041**
International business	36.6	84.0	0.000***
Local government department	23.5	28.6	0.714
State government department	75.5	56.5	0.099*
Federal government department	51.2	75.0	0.056**
Private non-profit organisation	50.0	61.9	0.375

Note: Flinders University n=81; University of Adelaide n=43
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level; *** p-value of 0.01 or less is a significant difference at a 99% confidence level

When respondents were questioned about the location of industry partners, several significant differences occur as presented in Table 7.17. The data indicates that the academics that were surveyed collaborate with a variety of partners.

The University of Adelaide collaborated significantly more with businesses in the northern region while Flinders University and the University of Adelaide collaborated with around the same number of businesses in the southern region. It was expected from the secondary data that Flinders University would collaborate more with government departments than the University of Adelaide and this was significantly seen for state government departments, but surprisingly the University of Adelaide collaborated with federal government departments significantly more than Flinders University. In addition, the University of Adelaide collaborate with interstate and international businesses significantly more than Flinders University. It would be expected from the secondary data that the University of South Australia would collaborate with businesses more than government departments and the majority of these business collaborations would be located in the northern region. It was noted that for each of the industry types, both universities had less than 5 partners for each type.

Respondents were asked about the nature of the industry partners they collaborated with and about their collaboration field. For Flinders University, the main nature of industry partners or field of collaboration under the categories of science and social sciences were:

- Science
    - Chemistry
    - Health and Medical
    - Biotechnology
    - Nanotechnology
- Social Science
    - Education
    - Economics
    - Law
    - Social Services

For the University of Adelaide, the main industry partners or field of collaboration were:

- Science
    - Engineering/Manufacturing
    - Biotechnology
    - Health
    - Environment/Chemistry
- Social Sciences
    - Management
    - Law
    - Economics

It can be seen that University of Adelaide respondents collaborate more with engineering and manufacturing businesses, of which some were advanced manufacturing businesses while Flinders University respondents don't. Both universities collaborate with similar partners in both the science and social science field. This is supported by the secondary data, which showed that the University of Adelaide had more engineering projects than Flinders University.

This could be due to the strength and size of the engineering faculty at the University of Adelaide. With a strong science and engineering industry background, the University of South Australia would probably collaborate significantly more with engineering, manufacturing and science partners than social science partners.

When asked about the outcomes of their industry projects, there were no significant differences between the universities (Table 7.18). Over 90% of respondents from both universities believe the outcomes of industry projects they had undertaken were successful. These successful outcomes mean that it is more than likely that respondents would undertake another project with an industry partner if it arose. This was verified by responses from the next question.

Table 7.18: Project outcomes and possibility of collaborating again

	Flinders University %	**University of Adelaide %**	*p*-value
Outcomes of industry projects are successful	91.4	92.7	0.815
Collaborate with previous industry partners again	93.0	95.2	0.421

Note: Flinders University n=81; University of Adelaide n=43

More than 90% of academics at each university responded that they would collaborate with previous industry partners again. This is supported by Lee (2000), who reported that over 90% of academics would maintain or expand their level of links with industry. Bonaccorsi and Piccaluga (1994) also support this high percentage of working together again by stating that if outcomes or performances met or exceeded their expectations partners involved in the collaboration would have an incentive to continue the relationship. In answering this question, respondents expressed why they would collaborate with industry partners again with the major reasons from both universities being:

- increased access to resources such as funds and equipment.
- research findings and outcomes have a ‘real world’ application.
- successful transfer of knowledge and services.
- level of trust had been developed.

The small number of academics who decided they would not collaborate with previous industry partners again stated the reasons were:

- research focuses too heavily on industry outcomes.
- the reporting and administrative requirements are too time consuming.

Respondents were asked about the extent to which industry collaborations support different factors. Table 7.19 shows the levels at which respondents considered statements about industry support.

Table 7.19: Percentage of respondents that thought industry supports to a great extent

Extent that industry support	**Flinders University %**	**University of Adelaide %**	*p*-value
obtain resources that are elusive from other sources	55.6	59.5	0.680
enhance academic productivity	39.4	45.2	0.545
increase career opportunities for students	61.1	59.5	0.867
increase the rate that outcomes of basic research are applied to industry problems	75.7	76.7	0.901
enhance reputation of university researcher	52.1	35.7	0.091*
increase knowledge exchange	68.1	65.1	0.874

Note: Flinders University n=81; University of Adelaide n=43
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level

For both universities, respondents (>75%) believed to a greater extent that industry support increases the rate at which the outcomes of basic research are applied to industry problems. Respondents also stated that industry support greatly increases knowledge exchange, career opportunities for students and allows respondents to obtain more resources. Flinders University respondents (52.1%) significantly stated that industry support enhances the reputation of a university researcher as opposed to University of Adelaide respondents (35.7%).

Respondents who had not had industry collaborations were asked the reasons why they hadn't.

There were a variety of different reasons expressed by the respondents from both universities but the reoccurring ones were:

- time – not enough to contact interested industry partners due to other commitments.
- agendas – hard to match university and industry requirements such as timelines, intellectual property and publishing research.
- research nature – research is fundamental in nature and so the research is not relevant to industry.
- difficulty – too hard to locate and initiate collaborations with industry.

Some of these factors could be overcome by implementing programs or offices that have the mission of matching industry partners to university research and then initiating contact between the interested parties. Even with these reasons, over 80% of respondents from both universities stated that they would consider an industry link in the future (Table 7.20).

Table 7.20: Percentage of respondents who would consider a future industry link

	Flinders University %	**University of Adelaide %**	*p*-value
Consider an industry link in the future	90.2	82.4	0.177

Note: Flinders University n=133; University of Adelaide n=80

The questionnaire investigated the factors that academics believe are important when an industry partner is attempting to collaborate with a university. As all the mean scores are above 2.5, then all the factors are considered by academics to be important to the industry partners (Table 7.21). There was a significant difference between the universities for academics believing that an industry partner views the reputation of the university as important when collaborating. Both universities ranked the personal relationship with a university researcher as the most important factor, which is probably due to academics forming relationships within industry through personal friendships and working on gaining trust from industry partners.

Table 7.21: Factors respondents believe industry partners find important when collaborating with a university

Factors	Flinders University#	University of Adelaide#	*p*-value
Reputation of university	3.48	3.04	0.026**
Personal relationship with a university researcher	4.00	4.08	0.708
Quality of researchers	3.99	3.98	0.956
University speciality	3.35	3.10	0.230
Ease of collaboration	3.82	3.92	0.561
Access to specialised equipment	3.26	3.15	0.598

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
** p-value of >0.01 to 0.05 is a significance difference between groups at a 95% confidence level

Respondents were asked if they believe the university does enough marketing to attract industry collaborations and whether industry knows how to discover the capabilities of academics within the university. Table 7.22 shows the percentages of respondents who agreed, and this table reveals that at both universities, nearly two thirds of academics believe the university needs to do more marketing to attract industry collaborations and promote the university skills and capabilities to industry.

Table 7.22: Percentages of respondents who believe the university does enough marketing towards industry collaborations

	Flinders University %	University of Adelaide %	*p*-value
University does enough marketing to attract industry collaborations	33.0	39.0	0.445
Industry knows how to discover the university and associated academics capabilites	25.2	22.0	0.646

Note: Flinders University n=133; University of Adelaide n=80

The questionnaire allowed academics at each university to state what they believed could be done to improve the level of industry collaborations. There was a wide range of opinions from respondents concerning what could be done to enhance these levels. The repeating statements from Flinders University respondents were:

- marketing/communication – increase the university's profile by marketing its respective skills, capabilities, research results and interests to regional and national businesses. Market benefits obtained from industry collaborations to academics through presentations.

- time/incentives – free academics' time from administrative and teaching duties to pursue industry collaborations by meeting potential industry partners through attending functions and networking. Incentives for academics who undertake research and collaborations with industry.
- industry office – dedicated office whose role is to match university researchers with potential industry partners. They would then quickly organise formal links with industry with minimal paperwork. This would be first place industry contacts to discuss possible links. Allows for researchers to cooperate and not compete for the same industry links.
- students – get industry involved in undergraduate courses and allow students to work in industry as part of their degree. Most university-industry relationships are formed from personal contact.

The major reoccurring statements from the University of Adelaide respondents were similar to Flinders University respondents, with an extra one being:

- IP/costs – clarify and reduce paperwork concerning intellectual property and outcomes from industry collaborations. Reduce the university costs from undertaking industry collaborations.

These data reveal that respondents from both universities believe that the university needs to make some changes to enhance university-industry collaboration levels especially in marketing the university to potential industry partners. They also reveal that respondents believe the university should take a more active role in establishing a specific industry office that matches industry requirements to academic capabilities.

The questionnaire asked academics at each university, what university they believed best collaborated or worked with industry. This question was purely subjective in trying to decide if there is a forgone feeling among academics at the universities relating to respective universities promoting industry collaborations.

Academics knowledge and opinion on this would be sourced from their own personal experiences of industry collaboration and exposure to publicity from other universities.

Table 7.23: Respondents deciding which university they believe works best with industry

University	Flinders University# Respondents	University of Adelaide# Respondents	*p*-value
Flinders University	2.23	2.61	0.003***
University of Adelaide	2.12	1.86	0.082*
University of South Australia	1.64	1.51	0.401

Note: # Figures in these columns represent mean scores - a value of 1 is collaborates best and a value of 3 is collaborates worst - the lower the score the better the university collaborates with industry
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence interval; *** p-value of 0.01 or less is a significant difference between groups at a 99% confidence level

Table 7.23 reveals that Flinders University respondents believed that the University of South Australia worked best with industry, while Flinders University collaborates poorly with university. This implies that academics know they don't work well with industry and from previous points, and evidence, this seems mainly to be due to the lack of marketing on what the university is capable of and has achieved, and not what the academic has experienced from their involvement with industry. Academics at the University of Adelaide ranked industry involvement in the same order, but significantly they viewed Flinders University as the worst and the University of South Australia as best. It would be anticipated that University of South Australia academics would have a perception that they collaborate well with industry and so would suggest they collaborate the best with industry out of the three universities.

7.3.4 Industry linked academics

The following data investigates the characteristics of respondents that have had industry links compared with respondents that have not had links with industry. A variety of benefits have been reported in literature for researchers who collaborate with industry such as increased funding, more students and increased number of publications.

Table 7.24 shows that at both universities, respondents that have had industry links have significantly greater number of honours students, PhD and master students, postdoctoral fellows and research assistants. Respondents from both universities with industry links have twice as many people in each category than respondents that haven't had industry links. This increase in group members would be because respondents who have industry links are more likely to have increased funding to employ more research assistants and offer scholarships and funding to PhD students. These extra students and research assistants would also allow industry researchers to undertake more collaboration with industry and increase their research and knowledge portfolio.

Table 7.24: Average number of research group members

	Flinders University#			University of Adelaide#		
	Industry	Non Industry	*p*-value	Industry	Non Industry	*p*-value
Honours	1.44	0.79	0.043**	1.92	0.39	0.001***
PhD/Masters	2.79	0.97	0.000***	3.00	0.65	0.000***
Post Docs/Research Assistants	1.26	0.48	0.008***	1.41	0.31	0.000***

Note: # Figures in these columns represent mean scores - the higher the value the more people supervised
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level; *** p-value of 0.01 or less is a significant difference between groups at a 99% confidence level

The publication record of respondents was considered and is shown in Table 7.25. It can be seen that 83.7% of respondents who haven't had industry links at Flinders University have published between 0 and 24 articles, and for the University of Adelaide it is 75%. For both universities, nearly 50% of respondents that have collaborated with industry have published more than 25 articles.

Table 7.25: Percentages for different levels of publishing articles

	Flinders University %			University of Adelaide %		
	Industry	Non Industry	*p*-value	Industry	Non Industry	*p*-value
0 - 24 articles	57.5	83.7	0.003***	51.1	75.0	0.052*
25 - 49 articles	18.8	7.0	0.078*	14.9	12.5	0.784
50 - 99 articles	17.5	4.7	0.043**	17.0	8.3	0.319
100+ articles	6.3	4.7	0.715	17.0	4.2	0.122

Note: Flinders University n=133; University of Adelaide n=80
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level; *** p-value of 0.01 or less is a significant difference at a 99% confidence level

As industry respondents have more group members (Table 7.24) this allows more articles to be published. These findings are consistent with Harman (1999), who found that industry funded researchers had more students and had published more papers. Harman argues that this opposes the notion that academics who work with industry neglect publishing papers in the wider academic community.

Table 7.26: Percentages for academics and their collaboration levels and beliefs

	Flinders University%			University of Adelaide%		
	Industry	Non Industry	*p*-value	Industry	Non Industry	*p*-value
Have worked in industry	65.0	50.0	0.108	53.2	50.0	0.799
Research is applicable to industry	92.5	72.1	0.002***	97.9	62.5	0.000***
Collaborated on projects with other schools/ faculties within the university	62.5	42.9	0.028**	53.3	25.0	0.023**

Note: Flinders University n=133; University of Adelaide n=80
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level; *** p-value of 0.01 or less is a significant difference at a 99% confidence level

It can be seen from Table 7.26 that respondents from both universities who have undertaken collaborations with industry have collaborated significantly more with other schools or faculties within the university and believe that their research is more applicable to industry. For both universities, 50% of respondents who have worked in industry have not had any collaborations with industry and over 62% of these respondents who haven't had collaborations with industry still believe their research is applicable to industry. It was expected that the percentage of respondents who had worked in industry but hadn't had any industry collaborations would have been significantly lower as they would understand the possible benefits available when collaborating with industry.

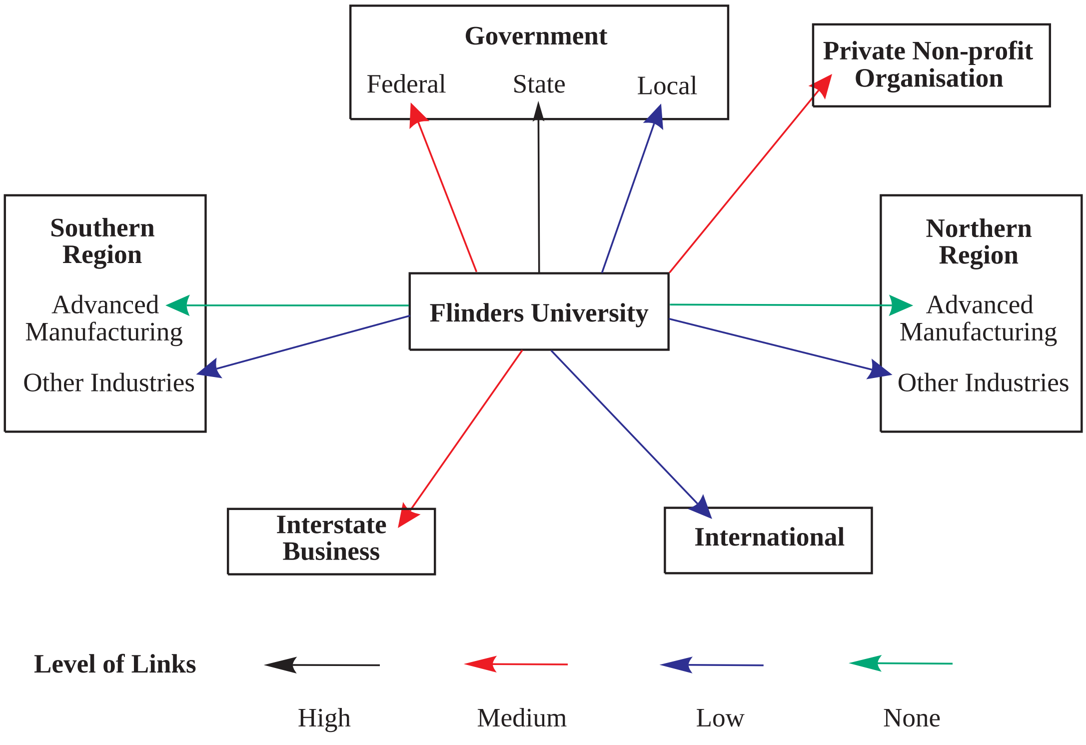
7.3.5 University Links Map

Condensing this data by representing the results in the form of a map provides a visual representation of the level of links with different industry partners.

7.3.5.1 Flinders University

The linkage map for Flinders University is shown in Figure 7.14. Flinders University main industry links are with government departments with high levels and medium levels of links with State and Federal government departments, respectively. Flinders University has medium number of links with interstate businesses and non-profit organisations. It has no links with advanced manufacturing businesses in either the southern or northern region and has low levels of links with other industries in both regions. This could be due to regional businesses being unaware of the university's capabilities or that the university's research and capabilities do not match regional business requirements.

Figure 7.14: Flinders University industry links map

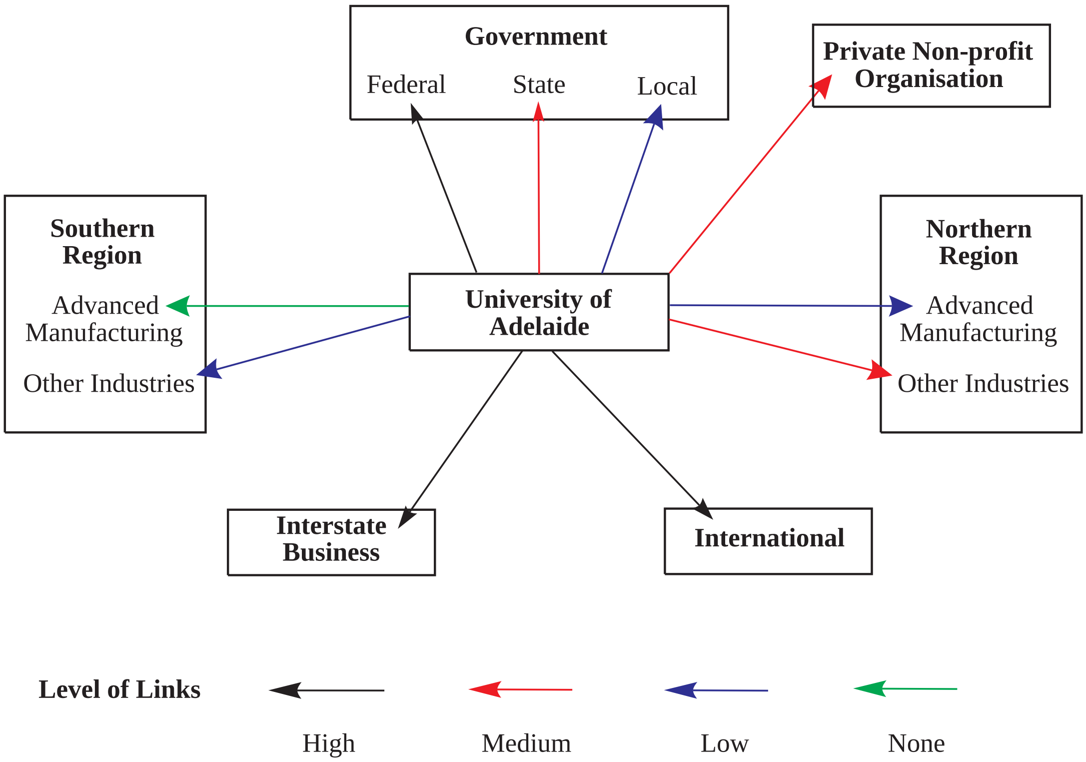


This means if the Flinders University wants to increase industry links and take an active role in regional development, it should market its capabilities to regional industries and take a lead in initiating links with these industries.

7.3.5.2 University of Adelaide

The linkage map for the University of Adelaide is shown in Figure 7.15. As opposed to Flinders University, links for the University of Adelaide are spread more across regional and interstate businesses, government departments and international businesses.

Figure 7.15: University of Adelaide industry links map



The University of Adelaide has high number of links with interstate and international businesses, and the Federal government. It also has medium to low level number of links with industries in the southern and northern region and a low number of links with advanced manufacturing businesses in the northern region. It has no links with advanced manufacturing businesses in the southern region. It probably has more links over wider range of industry partners due to its alignment with the Go8 grouping and its reputation as an excellent research institution.

7.4 Chapter Summary

Knowledge is now recognised as critical for economic growth, innovation and business competitiveness. University-industry links are becoming an important means for solving specific industry problems and for exchanging knowledge between universities and industry.

This chapter has analysed and described the types of links universities have with industry and nature of the industry partners different universities have collaborated with. The CRC and ARC Linkage programs have been implemented to increase the levels of collaboration between universities and industry. For the ARC Linkage projects scheme, industry partners provide the majority of funding and this level of funding has increased every year. Private businesses and government departments constitute the majority of industry partners. Most of the projects and partners are in the science and technology fields. The CRC program and ARC Linkage projects are dominated by the Go8 universities followed by the ATN universities.

Both Flinders University and the University of Adelaide academics recognise that university-industry links are important and represent a means for basic research to be applied to industry problems and to increase knowledge exchange. Both sets of academics agreed that university-industry links don't pose a threat to traditional university values. Academics from both universities regard personal interest as the main reason for choosing their field of research and not the possibility of commercial application of results of availability of funding.

Industry links for Flinders University academics are predominantly with government departments and are usually a private project or a consultancy to solve a specific business problem. The consultancy projects were driven by academics receiving extra funds and research opportunities. For the University of Adelaide academics collaborated with a range of industry partners which were private businesses, government departments and international businesses. These collaborations were mainly consultancies, ARC Linkage projects or private projects. The main driving forces for the consultancy projects were extra income and technology or research commercialisation.

A large number of academics from Flinders University and the University of Adelaide deemed that the outcomes of industry projects were successful and that they would collaborate with previous industry partners again. The reasons they would collaborate again ranged from the possibility of increased access to resources such as funds and equipment to successful transfer of knowledge and services and a level of trust had been achieved. Nearly all academics at both universities who haven’t had any links with industry stated that they would consider an industry collaboration in the future.

Academics that have collaborated with industry have more group members and publications than academics that haven’t collaborated with industry. These industry linked researchers also collaborate on projects with other schools and faculties within their university and believe their research is applicable to industry. Flinders University and University of Adelaide academics believe that their universities don’t do enough marketing to attract industry collaborations and industry is unsure of the universities’ capabilities. The academics suggested a variety of means for which university-industry levels can be enhanced, ranging from more marketing to creating a specific industry office to match researcher interests and capabilities to industry requirements.

Chapter Eight

Industry Case Study

8.1 Introduction

This chapter will discuss and interpret the information collected from the case study of different advanced manufacturing regions of Adelaide. Cluster elements and the components of these elements are important in classifying each cluster and so are investigated and analysed in this chapter. The strength and number of links or relationships with various different businesses and organisations such as universities and research institutions are investigated and the chapter also describes the characteristics and classifies each cluster in the study.

The case study is analysed using both quantitative and qualitative data. The initial quantitative data contained in this chapter is on industry locations and is based on Place of Work statistics from the ABS. The remaining quantitative and qualitative data is based on a questionnaire that was answered by advanced manufacturing business executives. The analysis of this data, allows for determination of the nature and extent of business relationships within the different clusters and to classify these regions. It is possible to compare the clusters to see relationships differ due to the businesses located within these clusters. This analysis approach, which was described in Chapter Six, will build an understanding of the types of advanced manufacturing clusters in each region.

The chapter is organised into a number of sections being: Section 8.2 outlines the structure and reporting of the case studies; Section 8.3 contains the relevant secondary data from the ABS; Section 8.4 contain the industry case study. Section 8.5 is the cluster relationship map and conclusions drawn from the case study and secondary data and confirms the answers to the questions introduced in section 8.2.

8.2 Case Study Structure

In organising the case study, secondary data was first analysed, followed by the primary data obtained from the questionnaire. It allows the key questions relating to business relationships and clusters characteristics to be answered and the two advanced manufacturing regions to be compared. A question and answer reporting format (Yin, 1994) was used to organise the case study. This format allows the same question to be addressed by different region business participants to allow for the critical questions to be answered in a concise manner.

The study approach is based on the framework that was described in Chapter Five, and the study areas chosen in this research were advanced manufacturing businesses located in the defined southern and northern regions. These regions encompass small advanced manufacturing cluster. The framework organises the information obtained through the secondary data and questionnaire to reflect business relationships and cluster characteristics. The questionnaire was distributed to business executives or manager at advanced manufacturing businesses in the southern and northern regions.

8.2.1 Questions

As stated in Chapter One, there exists a major question relating to this area supplemented by minor questions. Answers to the following questions were required for each of the regions:

- What are the advantages of being located in the particular region?
- How important are business relationships and the proximity of these relationships?
- What are the benefits of these relationships?
- How is knowledge and skills obtained in the industry?
- What is the nature and importance of links with universities?

Each question addresses a particular component of clusters and cluster processes. Most of the data used to answer these questions will be gained from the executives and managers who participated in the questionnaire. The answers from the questions will provide an assessment of the nature and extent of relationships in the advanced manufacturing industry, characteristics of co-location and whether these differ from region to region.

8.3 Business Location

Different regions for this case study were chosen, after a quantitative analysis indicated clustering of advanced manufacturing businesses. This clustering was confirmed by State government departments and agencies who had determined that there were small clusters of advanced manufacturing businesses in different regions.

The quantitative analysis utilised Place of Work (POW) data collected by the ABS during the 2006 census. POW provides information on where people work. The address of each employed person is used to code to a specific destination zone. This allows the significance of employment within different regions to be quantified. The POW replaced the Journey to Work (JTW) variable which was collected in previous censuses.

Different industry types can be recognised through their specific ANZSIC number. Location quotients (LQ) for the manufacturing sub-divisions of 23 through to 29 were calculated. This broad range of manufacturing divisions will capture any businesses that involved in the advanced manufacturing sector. The formula for determining the location quotient is shown in Figure 8.1.

Figure 8.1: Location Quotient Equation

$$\textbf{Location Quotient} = \frac{\left(\dfrac{\text{Regional Employment Industry Type A}}{\text{Total Regional Employment}}\right)}{\left(\dfrac{\text{Australian Employment Industry Type A}}{\text{Total Australian Employment}}\right)}$$

The location quotient compares the regional employment of a specific industry with the proportion of that industry in the Australian economy. A location quotient value of greater than one implies that the particular industry type is over represented in the region and this overrepresentation could be interpreted as a potential cluster. Table 8.1 shows the location quotient for manufacturing industries for the southern and northern regions.

Table 8.1: Location Quotient for industry sub-divisions involved in the advanced manufacturing sector

ANZSIC Category	Region	
	South	**North**
Motor Vehicle and Part Manufacturing	6.30	4.02
Photographic, Optical and Ophthalmic Manufacturing	5.90	3.25
Machine Tools and Part Manufacturing	1.22	1.32
Other Professional and Scientific Manufacturing	1.39	11.34
Electrical Equipment Manufacturing	1.98	4.35
Specialised Machinery and Equipment Manafacturing	1.38	2.92

This table reveals that for each of these regions the industry sub divisions involved in the advanced manufacturing sector were over represented as regional employers compared to their significance in the national economy. A drawback of using location quotient to determine if there is a possible cluster of the same industry type is that it doesn’t discriminate between the presence of a large single firm or a large number of small to medium enterprises that employ the same number of workers (Martin and Sunley, 2003). This is the case for automotive manufacturing as both regions have a single large firm which yields a LQ of over 9 for both regions. This location quotient issue is irrelevant for the advanced manufacturing industry, as nearly all the businesses involved in this industry are classified as small to medium sized.

8.4 Case Study

Analysis of the secondary data has revealed co-location of advanced manufacturing businesses in both regions. The primary data differs from the location quotient data in that it is both quantitative and qualitative in nature and investigates characteristics of this co-location and the relationships these businesses undertake. An understanding of theses characteristics and relationships will allow for determination of the nature and level of business links, and cluster classification. This case study is only investigating businesses that were deemed to be advanced manufacturing and no other businesses located in either the southern or northern region.

It will investigate the nature of relationships and their importance, whether these relationships are dependent on geographic proximity and factors that are important for business growth. Analysis of responses from the questionnaire will be presented in table form similar to the presentation in the university-industry links section where the first and second columns are the mean score or percentage of respondents for the southern region and northern region respectively. The final column is the *p*-value which represents if there is significant difference in values between the two regions. The mean score was determined by respondents indicating their level of agreement with statements through a five point Likert scale. A value of greater than 2.5 for the mean score suggests that the factor is important, while less than this means the factor is of little importance.

8.4.1 Business Features

The first section of the case study was to determine the business features of advanced manufacturing businesses in both regions. This provides an overview of the business size, inception, and business model since inception for each region. It can be seen in Table 8.2 that the nearly 50% of businesses in both regions employ between 20 and 99 people. The data also shows that 96% of businesses in both regions are classified as small medium enterprises (SMEs). Each region has only 1 or 2 businesses that are considered large firms and employ over 200 people.

Table 8.2: Percentage of people employed by businesses

Outcomes of Links	Southern Region %	Northern Region %	*p*-value
less than 5	10	8	0.73
5 to 19	34	30	0.58
20 to 99	44	48	0.67
100 to 199	8	10	0.73
greater than 199	4	4	0.94

Note: Southern Region n=28; Northern Region n=31
Percentage numbers have been rounded to the nearest whole number

Businesses were asked to nominate the way their business was created. Table 8.3 summarises the responses and shows over 50% of advanced manufacturing businesses were set up (spin off) by another business in both regions. Only a few businesses were spin offs from universities or research institutions and around 25% of businesses were an independent start up. There were no significant differences concerning the business creation ways for both regions. For the businesses set-up by another business or independent start-up the major reason for locating in the region were that the founding business was located in the region, the founding entrepreneur already resided in the area, or business opportunity.

Table 8.3: Method of business creation

Business Creation	Southern Region %	Northern Region %	*p*-value
Set up	56	60	0.746
Spin off	18	16	0.842
Independent start up	26	24	0.270

Note: Southern Region n=28; Northern Region n=31
Percentage numbers have been rounded to the nearest whole number

There were no significant differences regarding business development factors between the regions (Table 8.4). Advanced manufacturing businesses surveyed indicated that expanding sales within their original product or service market was the most important factor for business development since their inception (mean score greater than 3.8).

Businesses regarded diversifying by developing new products and services as important for business development, but not as important as the first factor. This implies that advanced manufacturing businesses in these regions are first strengthening their position in the market before expanding their business. This strengthening could entail innovation and R&D on their original products and services to capture more market share.

The mean score for the diversifying factor implies that some businesses have already obtained a strong position in the market and are diversifying into new products and services through internal or external R&D.

Table 8.4: Factors important for business development since inception of the business

Business Development	**Southern Region #**	**Northern Region #**	*p*-value
Expanding sales within your original product or service market	3.81	4.08	0.558
Diversifying by developing new products and services	3.32	3.38	0.890

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor

Leading on from this question, a number of factors relating to business development were presented to the respondents; the results are summarised in Table 8.5. This data shows that advanced manufacturing businesses in both regions regard business opportunity and proximity to local customers, suppliers, and sub-contractors as the most important factor for development or growth of their business. The availability and cost of premises and local government services are considered by businesses in both regions not to be an important factor. This suggests that businesses in both regions are located in the region for reasons other than costs.

There is little difference between both regions in this data, except that advanced manufacturing businesses in the northern region (mean score 3.64) view proximity to innovative people, ideas and technologies as important to their business development, whilst southern region businesses (mean score 3.05) do not. This difference is significant at the 90% confidence level. This implies that businesses in the northern region will have more strong links and collaborations with universities and research institutions. The factor of attractive local living environment would probably rank higher if the both regions were investigated as one region, as businesses have stated that this factor was one of the advantages of being located with that particular region.

Table 8.5: Importance of different factors for business development

Business Development Factors	Southern Region #	Northern Region #	*p*-value
Attractive local living environment	2.99	2.78	0.522
Local Infrastructure	2.67	3.14	0.248
Business Opportunity	3.99	4.07	0.759
Proximity to local customers	3.89	3.94	0.880
Proximity to local suppliers, subcontractors	3.96	4.06	0.786
Proximity to innovative people, ideas and technologies	3.05	3.64	0.097*
Supportive local government services	2.36	2.48	0.722
Availability and cost of appropriate premises	2.64	2.48	0.546

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
* p-value of >0.05 to 0.1 is a significance difference between groups at a 90% confidence level

8.4.2 Business Location and Links

The importance of relationships or links and their strengths can be determined by identifying and analysing business relationships in the cluster. This section reports the results from the questionnaire which posed questions on business relationships and location for advanced manufacturing businesses in the two regions.

In the first part of this section, respondents were asked to state the main advantages of their business being located in that region. Location features can have an influence on business and regional growth. For both regions the following factors were considered advantages of the region:

- lifestyle and living environment

- business opportunities
- access to suppliers and customers
- access to a skilled workforce
- availability of land for business premises

Respondents from the northern region noted that other advantages of the region were:

- Reputation of the region
- Access to research and training people

The listed advantages reveal that advanced manufacturing businesses in both regions view being located near suppliers, customers and a skilled workforce as a business advantage. This allows them to develop strong vertical and horizontal relationships with these co-located businesses. They believe the region offers them good business opportunities and there is an attractive living environment that will attract skilled workers to the region. For northern region businesses they view access to universities and training institutions as an advantage of being located in the region. This advantage allows them to develop strong links and collaborations with research institutions. The advantage of reputation of the region means that businesses in the northern region feel that its reputation as a growing region for high-technology and advanced manufacturing businesses will attract new businesses to the region, so creating new business opportunities and regional growth.

Business relationships or links between advanced manufacturing businesses and other categories of businesses or agencies were examined by asking respondents to identify how important business links were with other businesses. Table 8.6 shows the mean scores (responses) for this question. This data indicates that businesses from both regions regard business links with customers and suppliers as highly important (i.e. mean score greater than 4). However, both regions regard business links with their competitors as not important (i.e. mean score less than 2.5).

Table 8.6: Importance of business links with different categories of businesses

Business links with	Southern Region #	Northern Region #	*p*-value
Customers	4.04	4.19	0.563
Suppliers or subcontractors	4.08	4.13	0.850
Firms providing services	3.29	3.38	0.846
Research collaborators	2.79	3.32	0.056*
Competitors	2.36	2.45	0.561
Knowledge Base	2.64	3.26	0.041**

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significance difference between groups at a 95% confidence level

Business links with research collaborators or knowledge base businesses are significantly more important for businesses in the northern region than businesses in the southern region. This suggest that advanced manufacturing businesses in the northern region value knowledge and R&D important for their business and so are likely to collaborate with universities, research institutions or other businesses to conduct R&D or undertake innovative new projects. It is thought that the cluster benefit of high levels of innovation and R&D is due to the flow of knowledge and technology between linked businesses and universities.

As the importance of these different business links has been determined, the next question asked respondents how important was close geographical proximity for the development and maintenance of these links. The data obtained is summarised in Table 8.7. The table reveals that businesses in both regions regard geographic proximity as important for the development and maintenance of business links with suppliers (i.e. mean score greater than 4).

Table 8.7: Importance of geographical proximity for the development and maintenance of business links with different categories of businesses

Geographic proximity with	Southern Region #	Northern Region #	*p*-value
Customers	3.28	3.80	0.095*
Suppliers or subcontractors	4.04	4.16	0.649
Firms providing services	3.49	3.53	0.810
Research collaborators	3.04	3.65	0.089*
Competitors	2.64	2.44	0.391
Knowledge Base	3.02	3.46	0.096*

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
*p-value of >0.05 to 0.1 is a significance difference between groups at a 90% confidence level

The previous table indicated that business links with customers were important (i.e. mean score greater than 4), but businesses in the northern regions significantly regard geographic proximity as more important for these links than southern region advanced manufacturing businesses. Businesses from both regions don't regard geographic proximity as important for the limited number of business links they have with competitors. Significantly businesses in the northern region regard geographic proximity as important for the maintenance and development of links with research collaborators or knowledge base than southern region businesses. This means that advanced manufacturing businesses in the northern region are more likely to collaborate or have links with regional universities than universities located outside the region. This finding is supported by Acs *et al.* (1994) who reported that the level of knowledge spillover and transfer from universities decrease over distance and that these localised spillovers are more important for the innovative activities of high-technology SMEs.

The previous two tables summarised the responses of business links and the importance of geographical proximity to these links and so respondents were then asked to indicate from a list of benefits, the importance of benefits they obtained from these business links. The data to this question is presented in Table 8.8.

Table 8.8: Benefits obtained from business links

Benefits	Southern Region #	Northern Region #	*p*-value
Access to labour	3.66	3.62	0.920
Assuring a satisfactory quality of supplies	3.89	4.02	0.764
Assuring a timely delivery of supplies	3.84	3.98	0.788
Increasing market demand	4.02	3.96	0.864
More effective or innovative R&D	3.22	3.84	0.062*
Accessing new markets	3.36	3.98	0.068*
Accessing export markets	3.48	3.42	0.902
Enhancing reputation	3.22	3.62	0.088*

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
* p-value of >0.05 to 0.1 is a significance difference between groups at a 90% confidence level

The data shows that businesses in both regions view increasing market demand, satisfactory quality and timely delivery of supplies (i.e. mean scores greater than 3.75) as the main benefits of these business links. Significantly at a 90% confidence level, there a number of benefits those businesses from both regions regard differently. These include accessing new markets, enhancing reputation and more effective or innovative R&D. Advanced manufacturing businesses from the northern region view these benefits as more important than southern advanced manufacturing businesses. This benefit of more innovative R&D is the main reason, why businesses in the northern region have more links with universities, research institutions and research collaborators.

Northern region businesses also view the benefit of enhancing their reputation as an important benefit. This would allow them to increase their market share and access new markets and eventually lead to business growth and possible expansion. Business development can be increased by enhancement of their business reputation in conjunction with the stated northern region advantage concerning the reputation of the region as a high-technology advanced manufacturing cluster. As the reputation of the business and region are developed, other businesses recognise they have to be located in this region, near these businesses to capture cluster benefits such as business opportunities, business growth, knowledge spillovers, university collaborations and networking opportunities.

The final question of this section asked respondents to indicate the strength of any relationships their business has with other businesses and organisations within the region and outside the region (Table 8.9). A characteristic of clusters is the existence of strong local or regional relationships, and these local or geographic dependent relationships are a distinguishing feature between clusters and networks.

Table 8.9: Strength of regional and non-regional relationships for advanced manufacturing businesses

	Southern Region %				**Northern Region** %			
	Region		Non-region		Region		Non-region	
Business Relationships	Strong	Weak	Strong	Weak	Strong	Weak	Strong	Weak
Universities	30	34	38	18	52	30	32	20
Suppliers	56	18	48	18	69	20	44	28
Markets	44	18	44	24	52	18	48	20
Education and training	32	28	40	18	48	26	36	20
Skilled workforce	48	24	36	18	52	18	32	20
Research and development	28	28	34	24	56	26	36	24
Support Sevices	30	38	44	20	32	22	26	18
Industry Associations	48	28	40	24	52	22	20	24
Other businesses within the industry	18	34	20	20	32	30	26	28
Other industries	38	34	34	28	44	30	26	20

Note: Southern Region n=28; Northern Region n=31
Percentages have been rounded to the nearest whole number

These data indicates that businesses in the northern region have more strong links with businesses and groups in their region than non-region. Businesses in the southern region have about the same number of strong regional and non-regional links. In most of the business relationships, advanced manufacturing businesses have more strong links than weak, whether they are regional or non-regional. The data from this table will constitute a major part of constructing the cluster relationship map and classifying the cluster (Section 8.5).

8.4.3 Business Growth, Skills and Knowledge

In this section, respondents were asked a number of questions concerning different business factors that are important for the growth of their business. As advanced manufacturing businesses are classed as high-technology and they value tacit knowledge, skills and technologies. The factors that businesses considered important for business growth and development were determined by asking respondents to nominate from a list of different business factors. The data is summarised in Table 8.10.

Table 8.10: Importance of different factors for business growth and development

Factors	Southern Region %	Northern Region %	*p*-value
Local infrastructure	18	19	0.883
Competition	14	13	0.877
Labour	36	32	0.780
Available capital	36	38	0.812
Regional growth	28	52	0.072*
Innovation	54	74	0.099*
New markets	44	48	0.670
Research and development	50	71	0.099*
Education and training	43	64	0.095*
Reputation	39	56	0.232
Government grants	18	26	0.462
Lower input costs	64	62	0.812

Note: Southern Region n=28; Northern Region n=31
Percentages have been rounded to the nearest whole number
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level;

These data reveals that advanced manufacturing businesses in both regions have similar percentages for most of the factors. More than 50 percent of businesses in both regions consider lower input costs and innovation as the most important factors for business growth and development. Businesses in both regions don’t believe that competition, local infrastructure or government grants are as important for their growth.

When comparing the regions, there is a significant difference (90% level) between advanced manufacturing businesses regarding innovation, R&D, education and training, and regional growth. The northern region businesses view these factors more important for business growth and development than southern region businesses, which mean that northern region businesses value the importance of knowledge and skills. This will increase their knowledge and skills base, which will then allow them to innovate more. They also view regional growth as important and believe that as the region grows more businesses will be attracted there, which will increase spending on other regional factors such as physical and telecommunication infrastructure. Interestingly, 50% of southern region businesses regard innovation as important for business development, but have low and weak relationships with universities and research institutions.

Advanced manufacturing businesses rely on fast and efficient telecommunications to conduct R&D and to liaise with suppliers, customers and research collaborators. Respondents were asked in the questionnaire if they believe current broadband (internet) speed is sufficient for their business to grow and expand. The majority of businesses in both regions (greater than 75%) responded that, the available broadband speed was insufficient for their business and that speeds and infrastructure need to be improved

The questionnaire presented several different sources for advanced manufacturing businesses to obtain knowledge and skills. The advanced manufacturing industry view knowledge and skills as very important for the growth of their business. They value their technologies and knowledge, and see their levels of knowledge, skills and technologies as their major competitive advantage. Respondents were asked to indicate where they source knowledge and skills for their business.

The data for this question is summarised in Table 8.11.

Table 8.11: Importance of different sources for knowledge and skill development

Sources of knowledge	Southern Region #	Northern Region #	*p*-value
Other related regional businesses	3.32	3.92	0.086*
Other related non-regional businesses	2.78	2.98	0.218
Local universities	3.28	3.98	0.044**
Local training institutions	3.46	4.03	0.092*
Competitors	2.29	2.18	0.684
Consultancy firms	3.14	2.94	0.541
Industry Associations	2.96	3.06	0.764

Note: # Figures in these columns represent mean scores - a value of 1 is not important and a value of 5 is extremely important - the higher the score the more important the factor
* p-value of >0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significance difference between groups at a 95% confidence level

This data shows that advanced manufacturing businesses in both regions regard competitors and other related non-regional businesses as the least important sources for knowledge and skills development. Both regions regard universities, local training institutions and other related regional businesses as the most important sources for knowledge and skills development (i.e. mean score greater than 3.2). Significantly these sources are more important for businesses in the northern region than businesses in the southern region. There is a significant difference at the 95% level for universities acting as sources of knowledge and skills development.

To increase the level of innovation in businesses, university-industry links and commercialising new technologies, various programs and grants have been implemented by both State and Federal governments. Respondents were asked in the questionnaire if they were aware of these different programs and grants and if they had received any funding from them. The data for this question is represented in Table 8.12.

Table 8.12: Awareness and funding of State and Federal Government programs

	Southern Region %		Northern Region %	
Government Programs	Aware	Received Funding	Aware	Received Funding
Commercial Ready	42	6	40	8
Commercialising Emerging Technologies (COMET)	32	3	33	4
R&D Tax concession	63	29	60	32
Market Access Program (MAP)	22	4	27	7
Innovation Investment Fund	19	2	18	2
Tradestart	12	3	13	3
Austrade	68	31	74	34
Ausindustry	72	33	75	37
Regional Development Boards	22	3	25	4
ARC linkage program	10	3	11	2
Co-operative Research Centre (CRC)	9	1	11	2

Note: Southern Region n=28; Northern Region n=31
Percentage values have been rounded to the nearest whole number

Over 50% of businesses form both regions were aware of the R&D tax concession and AusIndustry and AusTrade grants. Nearly a third of businesses had received funding from these programs. For the other grants, less than 10% of businesses had received funding from them even though 20% of businesses were aware of these other grants. Interestingly, only a small percentage of advanced manufacturing businesses in both regions were aware of the ARC Linkage program and CRCs and only a few businesses have engaged in these programs. This is due to these businesses not requiring to undertake a linkage program or they are unsure what both programs entail and the benefits that can achieved by being involved in them.

8.4.4 Business Links with Universities

The final part of the study relates to university-industry links, with this section investigating advanced manufacturing business links with universities for the different regions. It is specifically investigating the links between businesses and the three South Australian universities of Flinders University, University of Adelaide and University of South Australia. The initial question asked respondents what universities they had links with. Table 8.13 shows that for Flinders University and other universities there are no significant differences between regions. More northern region businesses significantly have links with the University of Adelaide and University of South Australia. This table also shows that more advanced manufacturing businesses in the southern region have linkages with University of Adelaide and the University of South Australia than Flinders University which implies that these businesses are linking with universities for other reasons than proximity.

Table 8.13: University that business has links with

Links with	Southern Region %	Northern Region %	*p*-value
Flinders University	25	22.6	0.82
University of Adelaide	28.6	54.8	0.04**
University of South Australia	35.7	64.5	0.03**
Other University	10.7	12.9	0.79

Note: Southern Region n=28; Northern Region n=31
** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

Following on from this, respondents were asked in the questionnaire to nominate from a list, the type of links they had with universities. The data from Table 8.14 indicates that for both regions, university consultancy and collaborative research projects are the main types of links. There is also a considerably high number of informal links between universities and advanced manufacturing businesses in both regions. Businesses in the northern region had significantly more links that involved university consultancy and access to specialised equipment than businesses in the southern region.

Table 8.14: Types of links

Type of Links	Southern Region %	Northern Region %	*p*-value
Collaborative research project	42.9	67.7	0.054**
ARC linkage project	7.1	6.5	0.910
Involvement in a CRC	3.6	9.7	0.351
University Consultancy	53.6	54.8	0.922
Training Programme run by the university	21.4	22.6	0.915
Access to specialised technical equipment	17.9	38.7	0.077*
Informal	42.9	32.3	0.401

Note: Southern Region n=28; Northern Region n=31
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

Involvement by businesses in a consultancy or research project means that they would have access to the specialised technical equipment, but northern region businesses obviously access specialised equipment as a means for them to reduce costs by not purchasing expensive equipment. The table also reveals that there is only a small involvement from advanced manufacturing business in a CRC or ARC linkage project from both regions, which confirms the findings from Table 8.12. This low involvement could be because businesses in both regions are unsure of how to become involved in them or the benefits that are obtained from the programs.

Respondents were asked what the outcomes of links with universities were (Table 8.15). The major outcomes for both regions were new development of skilled graduates and new products/processes. The development of new products/processes was significantly more for southern region businesses than northern regions businesses. Only a small percentage of businesses from both regions regarded outcomes of links as reducing R&D costs.

Table 8.15: Outcomes of links with universities

Outcomes of Links	Southern Region %	Northern Region %	*p*-value
New products/processes	67.7	46.4	0.098*
Product/process improvements	45.2	39.3	0.64
Increased knowledge base	41.9	53.6	0.37
Development of skilled graduates	50.0	61.3	0.38
Reduce business R&D costs	26.6	22.6	0.61

Note: Southern Region n=28; Northern Region n=31
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level

When respondents were asked if they considered the link with a university to be beneficial, there were no significant differences between the regions as seen in Table 8.16. Nearly 90% of respondents from both regions believe that links with universities were beneficial to their business. As these links are considered beneficial, it is likely that businesses in both regions would undertake more links with universities if they were available. This was the next question asked in the questionnaire and Table 8.16 shows that over 50% of respondents from both regions would consider links with universities in the future. Significantly, more businesses from the northern region replied that they would consider future links than businesses from the southern region.

Table 8.16: Links with universities

Links	Southern Region %	Northern Region %	*p*-value
Beneficial to the business	89.3	93.5	0.56
Consider links with universities in the future	53.6	74.2	0.098*

Note: Southern Region n=28; Northern Region n=31
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level

Respondents, who had no links with universities, were asked to nominate from a list, the reasons they didn't have university links. Table 8.17 shows that the two major reasons were that the business didn't require one at the present moment and they had a lack of knowledge about university capabilities. The data indicates that 78.6% of southern region businesses didn't require a link which is significantly different than northern regions businesses (51.6%). Significantly, businesses in the southern region had difficulty locating who to contact at a university concerning potential links. A positive for future possible links between advanced manufacturing businesses and universities, was that businesses in both regions didn't consider the cost of a linkage as a major reason for not undertaking links with universities.

Table 8.17: Reasons businesses don't have links with universities

Reasons for no university links	Southern Region %	Northern Region %	*p*-value
Business doesn't require ons	78.6	51.6	0.03**
Cost of linkage	32.3	35.7	0.78
Lack of knowledge about university capabilites	60.7	54.8	0.64
Difficulty locating who to contact in the university about potential links	50	29	0.099*
Haven't considered it	46.4	51.6	0.69

Note: Southern Region n=28; Northern Region n=31
* p-value of .0.05 to 0.1 is a significant difference between groups at a 90% confidence level; ** p-value of >0.01 to 0.05 is a significant difference between groups at a 95% confidence level

8.5 Cluster Relationship Map and Classification

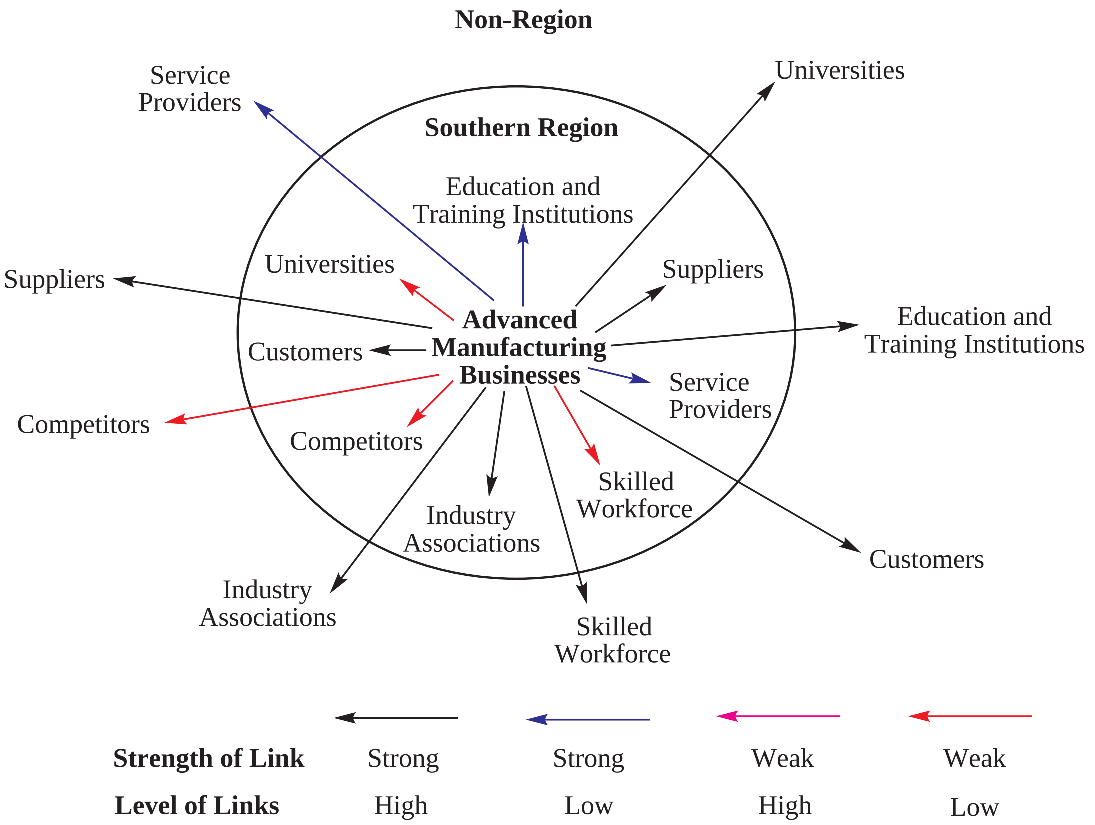
This section will classify the clusters for each region. The classifications are determined through the qualitative and quantitative data and the classification is based on the judgement of the researcher. As used in Chapter Seven, a map representing all the information from the data provides a visual tool for viewing the strengths and levels of relationships for each of the clusters. The map identifies the strength of relationships between the advanced manufacturing businesses, different businesses, and organisations within the region and outside the region. The map also reveals the level of links between the businesses, again both within the region and outside the region.

8.5.1 Southern Region

The cluster relationship (link) for the southern advanced manufacturing cluster and region is shown in Figure 8.2.

The map illustrates that the advanced manufacturing businesses in the southern region have strong and high levels of links with regional suppliers, customers and industry associations. It also has these types of links with suppliers, customers, industry associations, universities, skilled workforce and education and training institutions outside the region. The clustered businesses have low and weak relationships with regional universities, skilled workforce and education and training institutions which indicate that advanced manufacturing businesses in this cluster perform most of their R&D with universities outside the region than with regional universities. It also indicates that it is more likely to train and obtain skilled workers from outside the region.

Figure 8.2: Southern advanced manufacturing cluster relationship map



The advanced manufacturing cluster has minimal and weak relationships with competitors both in the region and outside the region and so is unlikely to be co-operating with any of these competitors to share R&D costs, infrastructure costs and knowledge.

8.5.1.1 Classification

When classifying clusters, economic, geographic and social dimensions need to be considered. Advanced manufacturing in the southern region is a highly significant industry and has a critical mass to obtain possible cluster benefits. There are a variety of advanced manufacturing business types producing a range of products for the economy. These businesses obtain inputs both regionally and non-regionally, however the levels of specialist service and education and training relationships are low and were identified to be both regional and non-regional. Geographically the region has a history of manufacturing and there is sufficient cheap land and infrastructure to allow the industry to grow. There are no geographic constraints to the enhancement of the advanced manufacturing cluster. The social dimensions identified included social infrastructure and networking with suppliers, customers and industry associations. Knowledge and R&D sharing along with relationships with universities and education and training institutions is underdeveloped regional but is adequate to well developed with non-regional bodies.

Based on the data and information obtained, this cluster of advanced manufacturing businesses displays the following characteristics:

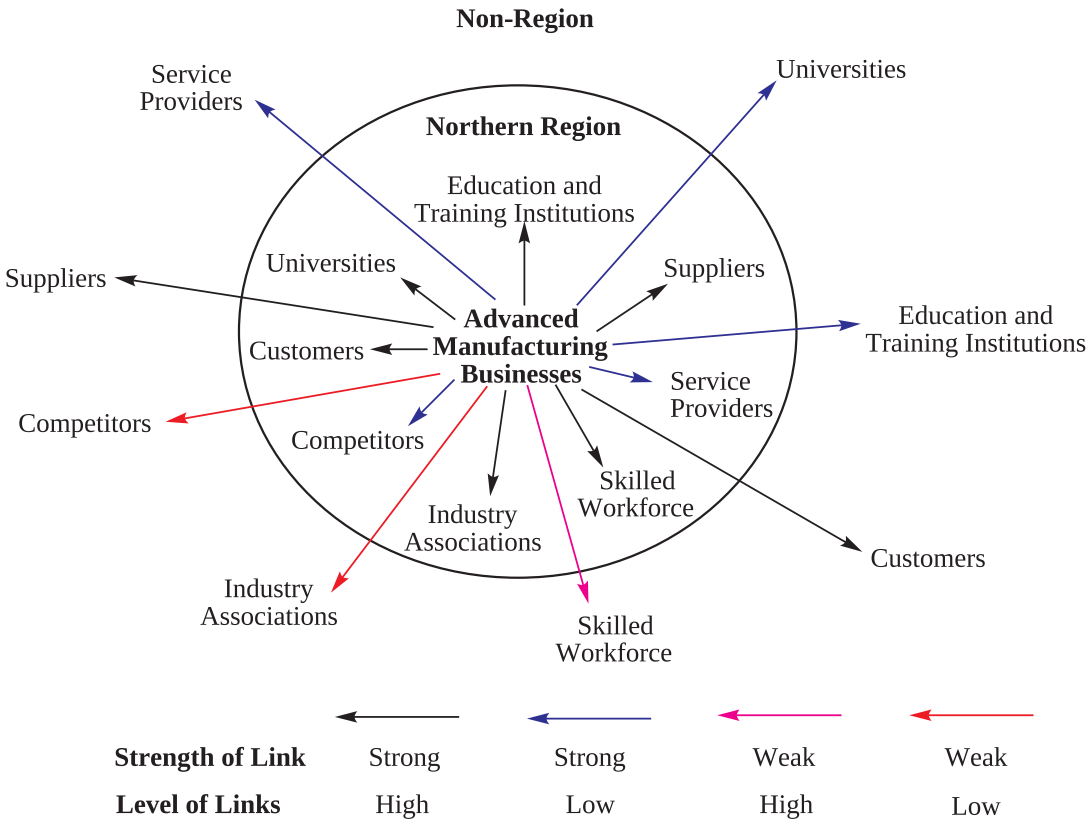
- geographically focused for some dimensions,
- economically significant industry and cluster, with potential to grow
- developed regional supply networks and integration
- relationship are limited and weak with local research organisations

This cluster has the characteristics which describe a **latent** cluster. A latent cluster has the characteristics of a critical mass of businesses sufficient to gain benefits from clustering, but has a low or insufficient level of interactions (formal or informal), knowledge and information flow, co-operation to take advantage of co-location. The advanced manufacturing businesses in the area of R&D and training do not exploit the potential benefits of clusters through closer and stronger relationships with regional universities, and education and training institutions.

8.5.2 Northern Region

The cluster relationship map for the northern advanced manufacturing cluster is shown in Figure 8.3.

Figure 8.3: Northern advanced manufacturing cluster relationship map



In this case the map shows that the advanced manufacturing businesses in the northern region have similar relationships with regional suppliers, customers and industry associations as the southern region. In the case of relationships with universities, skilled workforce and education and training institutions it differs from the southern region in that it has high levels of strong relationships with these regional research and training institutions. This means it is more likely to train workers and conduct R&D with regional institutions. These regional collaborations will keep the skills and knowledge developed in the region and so regional businesses will benefit from these spillovers more than non-regional advanced manufacturing businesses. The northern region shows more extensive and strong regional relationships as opposed to non-regional relationships. Like the southern cluster, it has limited relationships with regional and non-regional competitors.

8.5.2.1 Classification

The northern advanced manufacturing cluster is a highly significant and critical industry in the region and is growing. Geographically the region has a history of advanced manufacturing and the development of the defence cluster and technology park reveals there is a critical mass of high-technology businesses. The region has sufficient cheap land and infrastructure to allow the industry to develop and grow. The cluster has strong economic dimensions with developed vertical and horizontal links. There is a wide range of goods and services provided from within the region. Formal and informal networks have developed between businesses, suppliers and customers, industry associations and universities. Regional relationships with universities and education and training institutions are extensive and strong as well as adequate links with non-regional research bodies. These relationships imply that the innovative capacity of the region is good and this is an excellent benefit for business and cluster development. Along with the defence cluster the region is developing an identity and reputation of being a region able to support the growth of high-technology businesses. It has strong relationships with regional industry associations which are there to encourage and support advanced manufacturing business development in the cluster.

The data and information suggest that the northern advanced manufacturing cluster has strengths in all three elements and displays the characteristics:

- geographically dependent for nearly all dimensions
- dispersed throughout the region
- extensive and strong relationships both vertically and horizontally
- innovative with developed networks

- strength in social dimensions such as R&D and education
- strong relationships with universities, skilled workforce and education institutions
- values region reputation and has developed a certain identity

This cluster has characteristics that imply it is close to being a **working** cluster because it exhibits favourable cluster characteristics and a better level of business relationships that was not seen in the southern cluster. It is developing extensive networks both formal and informal and a critical mass of skills, expertise and knowledge. The cluster is developing an identity and reputation and is using co-location and co-operation benefits as an advantage.

8.6 Chapter Summary

The nature, level and extent of relationships between co-located businesses can affect business and regional growth. The use of cluster theory is becoming an important means for understanding these business relationships. Clusters and cluster processes can be used as a means to identify and describe small clusters or non-classified industry types that are overlooked or don't have an economic significance. It highlights the importance of cluster elements and dimensions and how they effect the formation and function of clusters. This approach allows business relationships of two advanced manufacturing clusters or regions of Adelaide to be identified and described; which in turn allows for classification of these clusters. It is important to note that this classification is based on the cluster framework and researcher's judgement as the characteristics and elements of each cluster are unique a ranking of the regions is not suitable for this study.

This chapter has analysed, identified, described and classified two different advanced manufacturing clusters in Adelaide. The location quotient data and evidence from various state government departments and bodies reveals that are there are two distinct advanced manufacturing clusters located south and north of the CBD of Adelaide.

There exist different cluster characteristics between the two regions. The northern region is strong in all three cluster elements of economic, geographic and social and so has been classified as a working cluster. It has strong links with regional universities and research institutions to develop knowledge and skills. Businesses in this region value the role R&D plays in their economic growth and believe that the reputation of the cluster will allow them a competitive advantage over their competitors. The southern region is not as strong in the three elements and as weak in regional links with universities and regional institutions. This lack of strength in the social element classifies this cluster as a latent cluster. Advanced manufacturing businesses located in this southern cluster are not exploiting the potential benefits of clusters and will only do so if they improve the strength of their links with these regional education and research institutions.

The outcome of this case study demonstrates that aspects of cluster theory that contribute to understanding relationships between co-located advanced manufacturing businesses allow for small clusters to be identified and classified.

Chapter Nine

Conclusions

9.1 Introduction

In this final chapter, the conclusions for both sections of the study are presented. The chapter will present initially the findings of the university-industry section followed by the cluster section of the study. The contribution that this study makes to university-industry links and small advanced manufacturing clusters is presented. The chapter describes a few strategies for enhancement of university-industry links and development of the advanced manufacturing clusters. The final part of the chapter identifies Future research directions for both business relationships and university-industry links that have arisen from this research.

9.2 Frameworks and Questions

9.2.1 Frameworks

The framework was an essential organisational platform for this study and allowed the research purpose, methodology, data collection and analysis to be connected. The framework allows for explanation of process and identification of the important aspects and elements of the phenomenon being investigated. For the university-industry section it identified key differences between the types of links, benefits of links and nature of partners. For the cluster section it identified the economic, geographic and social elements and dimensions that are embedded in clusters. The complexity of both sections being investigated has led to the development of a framework approach and this is justified and supported by the developed research methodology.

9.2.2 Questions

The initial research question in the first section of this study was to determine the nature and extent of university-industry links for three South Australian universities and whether their different alignments had an effect on these levels. In investigating this question, the study examined the types of linkages, nature of industry partners and benefits universities obtain from these links. The key questions or issues investigated were:

- the differences in the nature and levels of industry links for differently aligned universities.
- academic beliefs and views on fundamental research and industry links.
- benefits of linking with industry and the effect it has on traditional academic values.

The research question in the second section of the study was to investigate and define the nature of business relationships for two different advanced manufacturing regions of Adelaide and the effect location has on these relationships. To address this question, the study examined the clusters and cluster processes that exist in these clusters and the importance of different factors for business development and growth and were:

- drivers for business development and growth for advanced manufacturing businesses.
- the extent and strength of regional and non-regional business relationships.
- nature and importance of advanced manufacturing businesses collaborating with universities.

9.3 University-Industry Links

This study involved investigating, analysing and determining the characteristics of university-industry links for different aligned universities. Through the combination of descriptions of types of links by Perkmann and Walsh (2007) and Bonaccorsi and Piccaluga (1994) and descriptions of industry partners, this study differentiated the universities based on the classification of links and partners. This study was able to classify benefits from collaborations with industry based on described benefits and motivation by Valentín (2000) and from this academic opinions were offered on how to enhance and improve university-industry links. This study approach has shown there is diversity in industry partners, types of links and benefits for the different universities.

In investigating industry links from the CRC program and ARC Linkage program, analysis revealed that both programs in relation to the involvement in CRCs and number of projects and level of funding are dominated by Go8 universities. The majority of ARC linkage projects and partners are in the science/technology fields and industry partners provide the major funding for the projects. At the University of South Australia the majority partners are industry as opposed to Flinders University and the University of Adelaide which are mainly government departments. Nearly all the ARC Linkage projects and CRCs outcomes are aligned with the goals of the Backing Australia's Ability program.

Academics at Flinders University and the University of Adelaide recognise that industry links are important and allow for basic research to be aligned with industry problems. Academics at both universities don't believe that industry links threaten the traditional academic values of teaching and basic research and believe their university needs to undertake more marketing to attract industry partners. Flinders University has limited links with regional industries and none with advanced manufacturing businesses. It has very strong links with State government departments and these links are usually private projects or consultancies to solve a specific problem. The motivation for these private projects and consultancies are obtaining extra funds and research opportunities.

The University of Adelaide collaborates with private businesses, government departments and international businesses. It undertakes links with advanced manufacturing businesses in the northern region but not in the southern region. The links are mainly ARC Linkage projects, consultancies and private projects, with the consultancy motivation being research or technology commercialisation and extra income.

Benefits obtained by academics who undertake links as opposed to those who don't reinforce the findings presented by Harman (1999). Academics who undertake links or collaborations with industry have more postgraduate students, higher publishing rates and

9.4 Business Relationships

For this section, the study determined the cluster characteristics of the advanced manufacturing industry. It achieved this by investigating the cluster elements and dimensions that subsequently allowed the cluster to be classified. The cluster elements and dimensions described by Rosenfeld (1997) and Enright (2000) allowed the study to classify the clusters as wannabe, potential, latent or working and this classification allowed a differentiation of the advanced manufacturing clusters being studied.

Use of this approach has shown a difference in types of clusters between the studied regions and so there exists different cluster processes occurring in these clusters. The identification of these processes indicates the nature and strength of relationships in the cluster and the different factors considered essential for business and cluster development. Collaboration, joint activity and knowledge transfer and acquisition are features considered important for cluster development (Rosenfeld, 1997). Relationship building within the cluster is important and means cluster benefits remain regional and so become a regional asset.

The southern region study demonstrated that clusters can be identified and classified through an understanding of cluster elements and characteristics. The advanced manufacturing cluster in the southern region is classified as a latent cluster. It has geographic and economic cluster characteristics but shows limited social characteristics. Strong non-regional relationships rather than regional relationships are exhibited in this cluster. The cluster is geographically focused and has potential to grow but this potential is dependent on the cluster improving its collaborative relationships with universities, research institutions and other businesses. The cluster is not obtaining the cluster benefits due to the low levels of formal and/or informal knowledge and information relationships.

The findings in the northern region study suggest that this advanced manufacturing cluster is more developed than the southern cluster and is classified as a working cluster. It displays strong regional and non-regional relationships and has strength in all three cluster elements. The cluster is developing an extensive network of expertise and knowledge transfer as well as skills development, which are all essential for cluster development and growth. The cluster is developing a reputation with is significant for cluster growth. Reputation of regions has been suggested to enhance business credibility (Saxenian, 1990) and influence customers and/or businesses to locate in a particular region (Porter, 1998). The reputation of this cluster is providing it with a competitive advantage when compared to the southern region.

9.5 Benefits and Implications

The study has identified a number of benefits and implications related to university-industry linkages and cluster relationships and types.

9.5.1 Benefits

Actual benefits for both the industry partner and the university will be compared to the predicted benefits from literature for university-industry linkages. These will be discussed separately as there are different benefits for universities and industry.

The predicted benefits for the university (and academics) according to current literature are:

- Access to extra funding and resources
- Greater publications
- Enhanced career opportunities for students
- New and promising avenues of research

Comparison of academics involved with industry linkage projects to those without industry collaboration, showed:

- Increased access to funding, income, resources and equipment
- Transfer of knowledge, expertise and services
- Career opportunities for students and researchers
- Greater number and level of publications

Comparing actual benefits of university-industry linkages to the literature predicted benefits, showed significant similarities. Access to increased funding, income and resources was the most important identified benefit. By accessing more funding, academics are able to increase the number of researchers and students in their group. This increase in researcher numbers allows for more industry projects to be undertaken and also the possibility of more publications and income.

These identified actual benefits and linkage types reinforce the findings of Harman (1999, 2001), Lee (1996, 2000), Perkman and Walsh (2007, 2008), Bonaccorsi and Piccaluga (1994) and Valentin (2000).

For industry partners the predicted benefits of collaborating with universities are:

- Access to new knowledge, technologies and research
- Reduced R&D costs
- Shared risk involved in undertaking research.

The actual benefits identified for an industry partner involved in a university-industry linkage from this study are:

- Development of new products and processes
- Increased knowledge base
- Access to new knowledge and technologies
- Increased awareness of the value of R&D in economic growth.

The actual benefits to industry partners in university-industry linkages are consistent with the identified literature benefits. Access to new knowledge and technologies is the major benefit. This access allows firms to develop new products and processes which increase their productivity and boost the economy of the region.

A number of collaboration barriers were identified by respondents in this study which mirror the literature (Van Dierdonck *et al.*, 1990 and Hall *et al.*, 2001). Even with these barriers, this study has reinforced the findings of Harman (1999) and Lee (2000) that academics and industry partners embrace collaboration with considerable benefits offered to both parties.

9.5.2 Implications

This study has identified three consequences in relation to university-industry linkages and cluster relationships. The first involves the types of industry partners that universities choose to collaborate or link with. The university case study, indicates that universities with different group alignments such as Go8, ITN and ARU collaborate with different types of partners. This could be due to the different mission goals of each of the university groupings or the history of the university.

The second outcome is that the level and strengths of these linkages vary depending on the industry partner and their location. Universities will naturally develop stronger links with local firms and weaker links with more distant or international firms. The location of the industry partner in the linkage is also dependent on the expertise of the university. Firms will develop linkages with universities that have expert researchers in specific areas to improve their products or processes despite the university's location. Implicit to these implications is that if a particular university wants to increase industry links, it should market its capabilities Universities should develop key mechanisms for industry partners to enable ease of collaboration.

The third inference of this research concerns the type and/or maturity level of the advanced manufacturing industry clusters. This affects the number and strength of relationships and links with different firms and institutions, whether regional or not. The working cluster (northern region) has strong links with regional universities and institutions while the latent cluster (southern region) has minimal links with regional universities and institutions. The difference in the intensity and number links is causing one region to develop an extensive base of knowledge and skills. This is driving one region to develop a competitive advantage over other regions.

The strategies and recommendations for universities and regions that are discussed in Section 9.6 is underpinned by the above described benefits and implications.

9.6 Contributions and Strategies

9.6.1 Knowledge Contributions

This study has applied different concepts to understand university-industry links and business relationships in small clusters of advanced manufacturing businesses. It has resulted in an understanding of how different aligned universities collaborate with different types of industry and the important factors and relationships involved in small advanced manufacturing clusters. Although this study was directed at specific universities and advanced manufacturing clusters, there are findings from this study that may be utilised for other studies.

Firstly, this study has shown that a framework can be developed to understand university-industry links and can be used to identify the differences of these links for universities that have different goals, missions and research structures. The study has identified that universities collaborate with different industry types through different collaborating mechanism. An understanding of these characteristics allows universities to develop initiatives to improve the levels of these links.

The study has revealed that it appropriate to apply cluster theory to understand small and non-classified regional industries. Even though these clusters lack size and significance they represent unique regional characteristics and competencies that are important for regional growth and reputation.

The study demonstrates that cluster relationships are influenced by location and location plays a part in classifying clusters. Evidence of this is the strong relationships with regional universities and research institutions in the northern region when compared to the southern region. Strong regional relationships and location are fundamental for cluster success and development and identification of cluster relationships allows specific cluster or regional strategies to be developed to develop the cluster and region.

9.6.2 Strategies

As a result of understanding the different characteristics of university-industry links and cluster characteristics of specific manufacturing regions, an opportunity has developed to identify some strategies to that can be developed and implemented to enhance and improve university-industry links, and cluster development and growth.

Suggested strategies for Flinders University and the University of Adelaide, is to:

- reveal university's strengths and research capabilities through aggressive marketing.
- make academics more industry research orientated by reducing teaching time and administration duties.
- develop an industry liaison office to facilitate easy collaborations between industry and university academics.
- reduce the university's costs incurred by industry partners when collaborating with academics and researchers.

Possible approaches for the southern region advanced manufacturing cluster, is to:

- increase levels of links with universities and research institutions.

- develop clustering processes through more collaborative initiatives with regional businesses.
- develop links with other regional manufacturing and service sectors and clusters.
- develop closer links with industry associations and government bodies to

allow the cluster to develop a reputation as key advanced manufacturing region.

Approaches for the northern advanced manufacturing cluster to adopt, would be to:

- build upon reputation through marketing of regional strengths and attributes.
- maintain and grow involvement with other regional sectors and universities to increase collaborative activities.

Implementation of the strategies or only a few, would allow the universities and regional clusters to develop and grow. This would have an effect on regional economic growth and attract more businesses to the region which ultimately might seek collaborations with regional universities.

9.7 Future Research

The study has identified a number of features of university-industry links research and aspects of cluster research that could be further researched.

9.7.1 University-Industry Links Research Opportunities

The study has identified that there are differences between the type of linkages and nature of industry partners for differently aligned universities. Research could be conducted into the collaboration initiation process to understand who is driving the collaboration and the motivations for undertaking the collaboration. Differences in these motivations could impact on the success of the project. Research could also be undertaken on successful collaborative projects, to investigate the factors that lead to the project being successful or beneficial for the collaborating partners as opposed to unsuccessful university-industry collaboration.

9.7.2 Industry Cluster Research Opportunities

The study has shown that are different levels of relationships for different clusters of the same industry type. To understand why these differences occur is an area open to further research. Some areas that need to be addressed are the roles that larger businesses play in cluster development and knowledge development in small clusters and the reasons businesses are more active with certain universities and research institutions. Research could be conducted to investigate the relationships between advanced manufacturing clusters located inter-state or overseas to determine the effect these relationships have on the growth of the cluster and attraction of advanced manufacturing businesses to the cluster or region.

9.8 Conclusions

This study has reported on two interrelated research areas of business relationships and university industry links. The investigation of university-industry links identified and analysed industry collaborations between different universities. The business relationship section has used cluster theory to identify and analyse co-located small industry clusters.

The study has determined that universities aligned with different grouping have varying levels of industry links with different partners. Academics at universities believe that industry aligned research does not impact on traditional academic values. Industry linked academics exhibit different collaborating, group size and publication levels than non-industry linked academics. Different clusters exhibit different strengths in the different cluster elements and dimensions and economic, geographic and social elements have and these elements have an effect in determining the type of cluster. The types and levels of cluster relationships are dependent on location.

This study has developed framework components to organise and study university-industry links and small manufacturing clusters. It has shown that cluster theory can be applied to small cluster analysis. This study has highlighted that further examination of university-industry links in Australia is required and could consider other metropolitan universities and regional universities and more in-depth of linkage procedures. Also through this study, examination needs to be conducted on small clusters for different manufacturing sectors, investigating elements and relationships that exist. It is hoped that this study has highlighted the difference in industry links for the local universities and relationships for regional advanced manufacturing clusters; the results will assist these universities and clusters in developing strategies to increase cluster development and industry collaborations.

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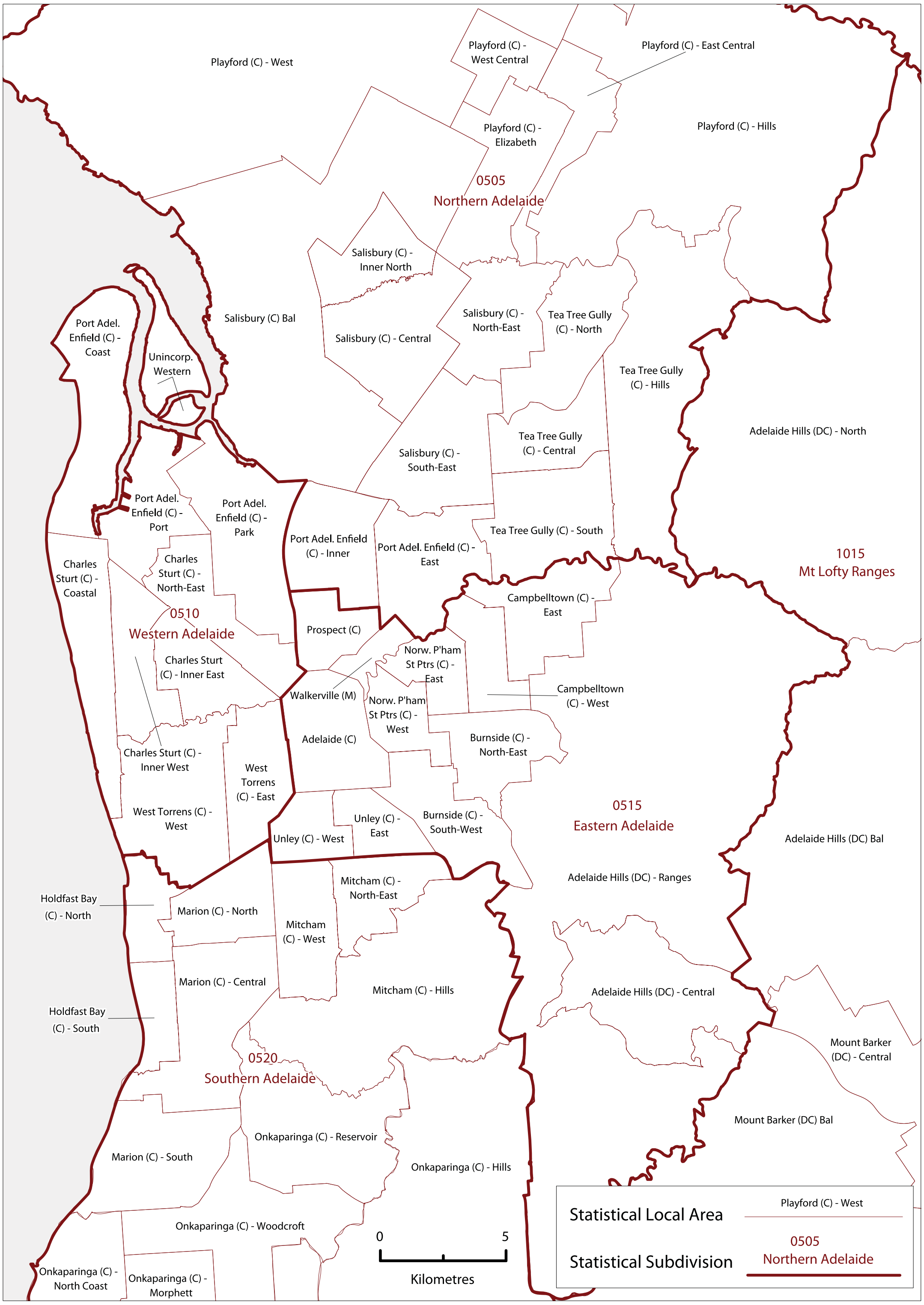
Appendix A

Statistical Subdivisions and Statistical Local Areas - Adelaide



Appendix B

Groupings of Australian Universities

Group of Eight (Go8)
- University of Adelaide
- Australian National University
- University of Melbourne
- Monash University
- University of New South Wales
- University of Queensland
- University of Sydney
- University of Western Australia

Australian Technology Network (ATN)
- Curtin University of Technology
- University of South Australia
- RMIT University
- University of Technology, Sydney
- Queensland University of Technology

Innovative Research Universities Australia (IRU)
- Flinders University
- Griffith University
- La Trobe University
- James Cook University
- Murdoch University
- University of Newcastle

New Generation Universities (NGU)
- Australian Catholic University
- Central Queensland University
- Edith Cowan University
- Southern Cross University
- Victoria University
- University of Ballarat
- University of Canberra
- University of Southern Queensland
- University of Sunshine Coast
- University of Western Sydney

Other Non-aligned Universities
- Macquarie University
- Charles Sturt University
- University of New England
- University of Wollongong
- University of Tasmania
- Deakin University

Swinburne University
Charles Darwin University
Bond University

Appendix C

Federal and State Government Programs and Grants

Program (Annual Expenditure)	Purpose and Type of Support
Commercial Ready $200 million	Stimulate greater innovation and productivity in the private sector . Wide range of activities can be supported, extending from initial research and Development (R&D) to early-stage commercialisation activities. Grants and loans to small companies.
Automotive Competitiveness & Investment Scheme (ACIS) $400 million	Encouraging new investment and innovation. Import duty credits based on investment in R&D and plant & equipment
Commercialising Emerging Technologies (COMET)	Aid the commercialisation of innovative products, processes and services. Business advice and management assistance
Industry Cooperative Innovation Program (ICIP) $5 million	Supporting business to business cooperation on innovation projects that enhance the productivity, growth and international competitiveness of Australian industries. Grants and loans
Innovation Investment Fund (IIF) $17 million	Promote commercialisation of Australian research and development. Venture capital injection into small, high-tech companies in their seed, start up or early expansion stage
Low Emissions Technology Demonstration Fund (LETDF) $33.3 million	Demonstrate break through technologies with significant long-term greenhouse gas reduction potential
Renewable Energy Equity Fund (REEF) $5 million	Encourages the development of companies that are commercialising R&D in renewable energy technologies. Provides venture capital.
Renewable Energy Development Initiative (REDI) $15 million	Supports renewable energy innovation and its early stage commercialisation. Offers grants and loans
R&D Tax Concession $400 million	125 per cent tax deduction for eligible R&D expenditure Incremental tax concession (175% premium) for companies who increase their level of R&D expenditure
Pre-seed Fund $10 million	Encourage the private sector to take a more active role in funding and managing the commercialisation of research from universities and Australian research agencies such as CSIRO, CRC, DSTO and ANSTO.
Pharmaceuticals Partnerships Program (P^3) $30 million	Increase the amount of high-quality pharmaceutical R&D activity in Australia at all stages of the pharmaceutical development process. Offers grants
Textile, Clothing & Footwear Strategic Invest Program (TCF SIP) $140 million	Foster investment, research and development and innovative product development. Offers grants

Cooperative Research Centres (CRCs) $155 million	Links researchers with industry to focus R&D efforts on progress towards utilisation and commercialisation
Major National Research Facilities (MNRF) $30 million	Funding for large equipment and specialised laboratories.
Australian Research Council Linkage Program $90 million	Collaborative research projects between higher education researchers and industry. Identifies an allocation to projects of benefit to regional and rural communities.
Rural industry and environmental R&D Corporations $300 million	Fosters development of new industries and develops a research program to address important issues facing the rural sector of Australia. 14 sector or commodity Based corporations.

Appendix D

University Academic Questionnaire

1. Invitation

Thank you for agreeing to take part in this survey. The outcomes from this survey will hopefully improve university-industry linkages and relationships.

Your time is valuable and I recognise this, so the survey should take about 10 minutes to complete. There are no correct or incorrect answers. I am only interested in your opinions relating to your collaboration with industry.

The survey and research is being undertaken by Paul Felici for the completion of a PhD at Flinders University.

Please use Next>> to navigate through the survey

2. Survey Information

Consent
Submission of the survey gives your consent to participate

Purpose of Survey
The survey investigates types of links between university researchers and industries and the views of researchers on these relationships

Confidentiality Issues
Personally identifiable information about you is not collected in this survey

Any information will be treated in the strictest confidence and none of the participants will be identifiable in the resulting thesis, report or other publication

You are entirely free to discontinue your participation

Results
Participants will be able to view a summary of results from this survey by contacting paul.felici@flinders.edu.au

Definition
For the purpose of this survey the term industry means both private and public sector commercial enterprises but excludes commercial arms of higher education institutes. The term also includes Commonwealth, State and Local agencies and private non-profit organisations which are users of research.

3. Academic Profile

In the first section of this survey I would like you to comment on your research career and values

1. What university division are you located in?

- ◯ Business
- ◯ Education, Arts and Social Sciences
- ◯ Health Sciences
- ◯ Information Technology, Engineering and the Environment

2. Please select the school, centre or institute you are located in?

Other (please specify)

3. Duration of employment as a university researcher?

4. Have you ever worked in industry?

◯ Yes ◯ No

5. How many Post Docs/Research Assistants, PhD and Honours students do you supervise?

Post Docs/Research Assistants [ ]

PhD/Masters [ ]

Honours [ ]

6. How many articles have you published?

○ 0-24 ○ 25-49 ○ 50-99 ○ 100+

7. The majority of these publications have been in?

☐ Journals ☐ Reviews ☐ Book Chapters ☐ Internal Industry Publications

8. How many were published in the last 3 years?

[ ]

9. Do you hold any patents?

○ Yes ○ No

10. Have you collaborated on projects with other divisions/schools within the university?

○ Yes ○ No

11. Indicate your agreement on each of the following statements towards academic values?

	Agree	Disagree	Neutral
University research should be investigator driven and not target orientated	○	○	○
Fundamental research is more important than applied research in a university environment	○	○	○
In order to be a good teacher, an academic must be active in research	○	○	○
Research results should be shared throughout the academic community	○	○	○

12. How important has the following been when choosing your field of research? Rank the importance of these factors on a scale from 1 to 5 where 1 is not important and 5 is extremely important

	1	2	3	4	5
Personal Interest	○	○	○	○	○
Likelihood of commercial application of results	○	○	○	○	○
Availability of funding from an industry source	○	○	○	○	○
Availability of funding from your own institution	○	○	○	○	○
Availability of funding from another source	○	○	○	○	○

Other (please specify)

13. Do you believe your research is applicable to industry?

○ Yes ○ No

4. Industry Projects

In this section I would like you to comment on whether you have worked with industry

14. Have you carried out any research or projects with an industry partner?

○ Yes ○ No

5. Industry Projects

15. Was this collaboration initiated by the industry partner or you?

○ You

○ Industry Partner

○ Combination of yourself and industry partners

16. Were these links formal, informal or a combination of both?

○ Formal ○ Informal ○ Both Formal and Informal

17. If formal, were these links:

☐ A Private Project

☐ A consultancy to solve a specific business problem

☐ Through an ARC Linkage project

☐ Business sponsorship of a course

☐ Other (please specify)

18. If you have undertaken a consultancy, what was the driving force? Tick all boxes that are applicable

☐ Opportunity (Income)
☐ Commercialisation (Technology Development)
☐ Research (Research Opportunities)

19. On average, what is the length in years of industry projects that you have undertaken?

○ 1 year
○ 2 years
○ 3 years
○ 4 years
○ Greater than 4 years

20. How many collaboartive industry projects have you commenced?

This year	
Last year	
2 to 5 years ago	
5 to 10 years ago	
10 years and onwards	

21. Do you consider the outcomes from most industry projects to be successful?

○ Yes
○ No

22. What is the main field of industry in which you collaborate? (ie: Biotechnology, Electronics, Medical, Economics etc...)

23. Please indicate the industry partners location/type? If yes, please indicate number of industry partners from these areas.

	Yes/No	Number of Partners
Onkaparinga, Marion, Holdfast Bay, West Torrens or Fleurieu Region Firm		
Playford, Enfield, Salisbury, Port Adelaide, Charles Sturt or Tea Tree Gully Region Firm		
Interstate Firm		
International Firm		
Local Government Department		
State Government Department		
Federal Government Department		
Private Non-Profit Organisation		

24. Which is more important to your research activities?

○ Industry related research
○ Academic related research
○ A combination of both industry and academic

25. Listed below are some possible benefits that can result from university researchers collaborating with industry. In your experience to what extent does industry support ....? Rank either great or small

	Extent
Obtain resources that are elusive from other sources	
Enhance academic productivity	
Increase career opportunities for students	
Increase the rate that outcomes of basic research are applied to industry problems	
Enhance reputation of university researcher	
Increase knowledge exchange	

26. Would you collaborate with previous industry partners again?

◯ Yes ◯ No

If yes, why?

27. If no, why not?

28. How many of your people are on industry projects, if any?

Honours

PhD / Masters

Post Docs / Research Assistants

6. Industry Projects

29. Have you applied for a government grant linked to industry?

◯ Yes ◯ No

30. What are some of the reasons why you have not had collaborations with industry?

31. If you haven't had industry links before, would you consider an industry link in the future?

◯ Yes ◯ No

7. University Industry Links

In this section I would like some general comments on university industry projects.

32. Indicate your agreement on each of the following statements towards links with industry

	Agree	Disagree	Neutral
It is exciting working with industry	○	○	○
I like consultancy work because of the additional earnings	○	○	○
The ARC linkage projects have been a success	○	○	○
Industry links pose threats to traditional values	○	○	○

33. In your opinion, what do you think industry partners find most important when collaborating with a university? Please rank the importance of these factors on a scale from 1 to 5 where 1 is not important and 5 is extremely important

	1	2	3	4	5
Reputation of University	○	○	○	○	○
Personal Relationship with a University Researcher	○	○	○	○	○
Quality of Researchers	○	○	○	○	○
University Speciality	○	○	○	○	○
Ease of Collaboration	○	○	○	○	○
Access to Specialised Equipment	○	○	○	○	○

34. Do you believe your university does enough marketing to attract industry to collaborate with university researchers?

○ Yes ○ No

35. Do you believe it is easy for industry to discover the capabilities of the university and associated academics and researchers?

○ Yes ○ No

36. Does yor school/faculty encourage you to undertake industry projects?

○ Yes ○ No

37. What do you believe could be done to further enhance university - industry links?

[ ]

38. Rank the following universities from 1 to 3 in the order you believe best collaborate with industry with 1 being the best university and 3 being the least.

Flinders University [ ]

University of Adelaide [ ]

University of South Australia [ ]

39. If you have any further comments please discuss them below

8. Thank You

Thank You for your time in completing this survey.

All answers will be confidential.

If you are interested in the results from this survey please contact me.

Advanced Manufacturing Questionnaire

1. Invitation

Thank you for agreeing to take part in this survey. The outcomes will hopefully improve economic development in local regions and expansion of advanced manufacturing businesses.

The survey and research is being undertaken by Paul Felici for the completion of a PhD in Business/Science at Flinders University.

Your time is valuable and I recognise this, so the survey should only take about 10 to 15 minutes to complete. There are no correct or incorrect answers. I am only interested in your opinions relating to your business links and the region.

The answers provided by you will allow a better understanding of the nature and extent of business links within regions and what effects these links have on the economic growth of businesses in the advanced manufacturing sector and regions.

Please use Next>> to navigate through the survey.

2. Survey Information

Consent
Submission of the survey gives your consent to participate

Purpose of Survey
The survey investigates interactions between businesses in different manufacturing regions of South Australia.

Confidentiality Issues
Personally identifiable information about you or your business is not collected in this survey

Any information will be treated in the strictest confidence and none of the participants will be identifiable in the resulting thesis, report or other publication.

You are entirely free to discontinue your participation

Results
Participants will be able to view a summary of results from this survey by contacting paul.felici@flinders.edu.au

Definition
For the purpose of this survey the term "region" means the region you select to answer Question 1 (Southern Region or Northern Region)

3. Business Features and Capabilities

*** 1. What region is your business located in?**

○ Southern (Onkaparinga, Marion, West Torrens, Holdfast Bay or Fleurieu)　○ Northern (Playford, Enfield, Salisbury, Port Adelaide, Charles Sturt or Tea Tree Gully)

2. How many people does your business employ?

○ less than 5　○ 5 to 19　○ 20 to 99　○ 100 to 199　○ greater than 200

3. What percentage of your employees have a tertiary qualification?

○ 0-10　○ 11-25　○ 26-50　○ Greater than 50

4. Was your business created by another business, a spin-off from an existing business/institution or an independent start up?

○ Set Up　○ Spin Off　○ Independent Start Up

5. If a new start up, why was this region chosen for it to be located in?

6. How important have the following been for the business's development since creation? Please rank the importance of these factors on a scale from 1 to 5 where 1 is not important and 5 is extremely important

	1	2	3	4	5
Expanding sales within your original product or service market	○	○	○	○	○
Diversifying by developing new products and services	○	○	○	○	○

4. Business Location and Links

In this section I would like you to comment on the advantages and disadvantages of your business location and the links your business has with other businesses.

7. What do you see as the main advantages to your business of being located in this region?

8. How important have the following factors been for your business development? Please rank the importance of these factors on a scale from 1 to 5 where 1 is not important and 5 is extremely important.

	1	2	3	4	5
Attractive local living environment	○	○	○	○	○
Local Infrastructure	○	○	○	○	○
Business Opportunity	○	○	○	○	○
Proximity to local customers	○	○	○	○	○
Proximity to local suppliers, subcontractors	○	○	○	○	○
Proximity to innovative people, ideas and technologies	○	○	○	○	○
Supportive local government services	○	○	○	○	○
Availibilty and cost of appropriate premises	○	○	○	○	○

Other (please specify)

9. What would you say are the main disadvantages associated with your business being located in this region?

10. Please indicate the location of the businesses or organisations with which your business has links or contacts? (Tick more than one box if applicable)

	Region	State	National	International
Clients or customers	☐	☐	☐	☐
Suppliers of materials	☐	☐	☐	☐
Service Providers	☐	☐	☐	☐
Competitors	☐	☐	☐	☐
Consultants	☐	☐	☐	☐
Commercial Laboratories	☐	☐	☐	☐
Universities	☐	☐	☐	☐
Federal Government Institutions	☐	☐	☐	☐
Industrial Associations	☐	☐	☐	☐

Other (please specify)

11. How important are your business links with the following? Please rank the importance of these factors on a scale from 1 to 5 where 1 is completely not important and 5 is highly important

	1	2	3	4	5
Customers	○	○	○	○	○
Suppliers or subcontractors	○	○	○	○	○
Firms providing services	○	○	○	○	○
Research Collaborators	○	○	○	○	○
Competitors	○	○	○	○	○
Knowledge Base	○	○	○	○	○
Other	○	○	○	○	○

Other (please specify)

12. How important is close geographical proximity to the development and maintenance of such links? Please rank the importance of these factors on a scale from 1 to 5 where 1 is completely not important and 5 is highly important

	1	2	3	4	5
Customers	○	○	○	○	○
Suppliers or subcontractors	○	○	○	○	○
Firms providing services	○	○	○	○	○
Research Collaborators	○	○	○	○	○
Competitors	○	○	○	○	○
Knowledge Base	○	○	○	○	○
Other	○	○	○	○	○

Other (please specify)

5. Business Location and Links

13. Where links are important, which of the following do you consider to be the main benefits? Please rank the significance of these factors on a scale from 1 to 5 where 1 is completely insignificant and 5 is highly significant

	1	2	3	4	5
Access to labour	○	○	○	○	○
Assuring a satsifactory quality of supllies	○	○	○	○	○
Assuring a timely delivery of supplies	○	○	○	○	○
Increasing market demand	○	○	○	○	○
More effective or innovative R&D	○	○	○	○	○
Accessing new markets	○	○	○	○	○
Accessing export markets	○	○	○	○	○
Enhancing reputation	○	○	○	○	○

Other (please specify)

14. Please indicate the strength (strong or weak) of any relationships that your business has with other groups, both within the region and outside the region. Answer all relevant parts.

	Region	Non-Region
Universities		
Suppliers		
Markets		
Education and Training Institutions		
Skilled Workforce		
Research and Development		
Industry Associations		
Support Services		
Other Businesses within Industry		
Other Industries		

6. Business Growth

In this section I would like you to comment on different business factors that are important for the growth of your business.

15. Do you believe current available broadband speed is sufficient for your business to grow and expand?

○ Yes ○ No

16. Select from the following list of factors those which you consider are important for the growth and development of your business? Tick all relevant boxes.

- ☐ Local Infrastructure
- ☐ Competition
- ☐ Labour
- ☐ Available Capital
- ☐ Regional Growth
- ☐ Innovation
- ☐ New Markets
- ☐ Research and Development
- ☐ Education and Training
- ☐ Reputation
- ☐ Government Grants
- ☐ Lower Input Costs

Other (please specify)

7. Business Growth

17. How important are the following as sources of knowledge and skill development for your business? Please rank the importance of these factors on a scale from 1 to 5 where 1 is completely not important and 5 is highly important

	1	2	3	4	5
Other related businesses from within the region	○	○	○	○	○
Other related businesses from outside the region	○	○	○	○	○
Local Universities	○	○	○	○	○
Local training institutions	○	○	○	○	○
Competitors	○	○	○	○	○
Consultancy firms	○	○	○	○	○
Industry Associations	○	○	○	○	○

Other (please specify)

18. Your business may obtain and transfer knowledge in different ways and at various speeds. Please comment below on how you obtain new knowledge and skills in your business.

19. Are you aware of support programs from the State and Federal Governments and have you received funding from these programs?

	Aware	Received Funding
Commercial Ready	☐	☐
ARC Linkage Program	☐	☐
Commercialising Emerging Technologies (COMET)	☐	☐
R&D Tax Concession	☐	☐
Market Access Program (MAP)	☐	☐
Innovation Investment Fund	☐	☐
TradeStart	☐	☐
Austrade	☐	☐
AusIndustry	☐	☐
Co-operative Research Centres (CRC)	☐	☐
Regional Development Boards	☐	☐

Other (please specify)

8. University Links

In this section I would like you to comment on any links with universities

20. Has you business had links with a university department or academic?

○ Yes ○ No

9. University Links

21. Which universities have you had links with? Tick all that apply

☐ Flinders University

☐ University of Adelaide

☐ University of South Australia

☐ Other University

22. Please tick any of the following which best describe you links? Tick more than one box

- ☐ Collaborative research projects with university departments or academics
- ☐ An ARC linkage project
- ☐ Involvement in a Commonwealth Research Centre (CRC)
- ☐ University staff acting as consultants
- ☐ Training programmes or courses run by the University
- ☐ Access to specialised technical equipment
- ☐ Informal

Other (please specify)

23. Were the links beneficial to your business?

○ Yes ○ No

24. What were the outcomes of these university links? Tick all relevant boxes

- ☐ New product/processe
- ☐ Product/process improvements
- ☐ Increased knowledge base
- ☐ Development of skilled graduates
- ☐ Reduce business R&D costs

Other (please specify)

10. University Links

25. Tick any of the following why your business doesn't have links with universities?

- ☐ Business doesn't require one
- ☐ Cost of linkage
- ☐ Lack of knowledge about the university capabilities
- ☐ Difficulty locating who to contact in the university about potential links
- ☐ Haven't considered it

Other (please specify)

26. Would you consider links with a university in the future?

○ Yes ○ No

27. Which of the following do you believe are the most important when a business is looking to collaborate with a university? Please rank the importance of these factors on a scale from 1 to 5 where 1 is not important and 5 is extremely important.

	1	2	3	4	5
Reputation of the University	○	○	○	○	○
Personal Relationship with a University Researcher	○	○	○	○	○
Quality of Researchers	○	○	○	○	○
Universities Speciality	○	○	○	○	○
Ease of Collaboration	○	○	○	○	○
Access to Specialised Equipment	○	○	○	○	○

Other (please specify)

28. If you have any further comments about your business links or the region please discuss them below

11. Thank You

Thank You for your time in completing this survey.

All answers will remain confidential.

If you have any questions about the survey or are interested in its findings please contact paul.felici@flinders.edu.au

Appendix E

Cooperative Research Centres

Manufacturing Technology

CAST
Advanced Automotive Technology
Advanced Composite Structures
Bioproducts
Construction Innovation
Functional Communication Surfaces
Intelligent Manufacturing Systems and Technologies
microTechnology
Polymers
Railway Engineering and Technologies
Welded Structures
Wood Innovations

Information and Communication Technology

Interaction Design
Photonics
Telecommunications
Capital Markets
Enterprise Distributed Systems
Integrated Engineering Asset Management
Sensor Signal and Information Processing
Smart Internet Technology
Spatial Information

Mining and Energy

Clean Power from Lignite
Coal in Sustainable Development
Greenhouse Gas Technologies
Landscape Environments and Mineral Exploration
Predictive Mineral Discovery
Sustainable Resource Processing
Mining
Integrated Hydrometallurgy Solutions

Agriculture and Rural Based Manufacturing

Emerging Infectious Diseases
Sheep Industry
Cotton Catchment Communities
Internationally Competitive Pork Industry
Beef Genetic Technologies
Forestry
Innovative Dairy Products
Innovative Grain Food Products

National Plant Biosecurity
Sugar Industry Innovation through Biotechnology
Sustainable Aquaculture of Finfish
Australian Poultry Industries
Tropical Plant Protection
Value Added Wheat
Viticulture
Molecular Plant Breeding

Environment

Bushfire
Antartic Climate and Ecosystems
Australian Weed Management
Coastal Zone, Estuary and Waterway Management
Contamination Assessment and Remediation of the Environment
Greenhouse Accounting
Irrigation Futures
Plant Based Management of Dryland Salinity
Sustainable Tourism
Great Barrier Reef World Heritage Area
Tropical Rainforest Ecology and Management
Tropical Savannas Management
Water Quality and Treatment
Desert Knowledge
Environmental Biotechnology
eWater
Invasive Animals

Medical Science and Technology

Aboriginal Health
Asthma and Airways
Biomedical Imaging Development
Chronic Inflammatory Diseases
Cochlear Implant and Hearing Aid Innovation
Diagnostics
Oral Health Science
Vaccine Technology
Vision

Appendix F

Australian Standard Research Classification (ASRC)

Division	*Discipline*	*Subject*
2100		**Science-General**
2200		**Social Sciences, Humanities and Arts-General**
2300		**Mathematical Sciences**
	2301	Mathematics
	2302	Statistics
	2399	Other Mathematical Sciences
2400		**Physical Sciences**
	2401	Astronomical Sciences
	2402	Theoretical and Condensed Matter Physics
	2403	Atomic and Molecular Physics
	2404	Optical Physics
	2405	Classical Physics
	2499	Other Physical Sciences
2500		**Chemical Sciences**
	2501	Physical Chemistry
	2502	Inorganic Chemistry
	2503	Organic Chemistry
	2504	Analytical Chemistry
	2505	Macromolecular Chemistry
	2506	Theoretical and Computational Chemistry
	2599	Other Chemical Sciences
2600		**Earth Sciences**
	2601	Geology
	2602	Geophysics
	2603	Geochemistry
	2604	Oceanography
	2605	Hydrology
	2606	Atmospheric Sciences
	2699	Other Earth Sciences
2700		**Biological Sciences**
	2701	Biochemistry and Cell Biology
	2702	Genetics
	2703	Microbiology
	2704	Botany
	2705	Zoology
	2706	Physiology
	2707	Ecology and Evolution
	2708	Biotechnology
	2799	Other Biological Sciences
2800		**Information, Computing and Communication Sciences**
	2801	Information Systems
	2802	Artificial Intelligence and Signal Processing
	2803	Computer Software
	2804	Computation Theory and Mathematics

	2805	Data Format
	2899	Other Information, Computing and Communication Sciences
2900		**Engineering and Technology**
	2901	Industrial Biotechnology and Food Sciences
	2902	Aerospace Engineering
	2903	Manufacturing Engineering
	2904	Automotive Engineering
	2905	Mechanical and Industrial Engineering
	2906	Chemical Engineering
	2907	Resources Engineering
	2908	Civil Engineering
	2909	Electrical and Electronic Engineering
	2910	Geomatic Engineering
	2911	Environmental Engineering
	2912	Maritime Engineering
	2913	Metallurgy
	2914	Materials Engineering
	2915	Biomedical Engineering
	2916	Computer Hardware
	2917	Communications Technologies
	2918	Interdisciplinary Engineering
	2999	Other Engineering and Technology
3000		**Agricultural, Veterinary and Environmental Sciences**
	3001	Soil and Water Sciences
	3002	Crop and Pasture Production
	3003	Horticulture
	3004	Animal Production
	3005	Veterinary Sciences
	3006	Forestry Science
	3007	Fisheries Science
	3008	Environmental Sciences
	3009	Land, parks and Agriculture Management
	3099	Other Agricultural, Veterinary and Environmental Sciences
3100		**Architecture, Urban Environment and Building**
	3101	Architecture and Urban Environment
	3102	Building
	3199	Other Architecture, Urban Environment and Building
3200		**Medical and Health Science**s
	3201	Medicine General
	3202	Immunology
	3203	Medical Biochemistry and Clinical Chemistry
	3204	Medical Microbiology
	3205	Pharmacology and Pharmaceutical Sciences
	3206	Medical Physiology
	3207	Neurosciences
	3208	Dentistry
	3209	Optometry
	3210	Clinical Sciences

	3211	Nursing
	3212	Public Health and Health Services
	3213	Complementary/Alternative Medicine
	3214	Human Movement and Sports Science
	3299	Other Medical and Health Sciences
3300		**Education**
	3301	Education Studies
	3302	Curriculum Studies
	3303	Professional development of Teachers
	3399	Other Education
3400		**Economics**
	3401	Economic Theory
	3402	Applied Economics
	3403	Economic History and History of Economic Thought
	3404	Econometrics
	3499	Other Economics
3500		**Commerce, Management, Tourism and Services**
	3501	Accounting, Auditing and Accountability
	3502	Business and Management
	3503	Banking, Finance and Investment
	3504	Transportation
	3505	Tourism
	3506	Services
	3599	Other Commerce, Management, Tourism and Services
3600		**Policy and Political Science**
	3601	Political Science
	3602	Policy and Administration
	3699	Other Policy and Political Science
3700		**Studies in Human Society**
	3701	Sociology
	3702	Social Work
	3703	Anthropology
	3704	Human Geography
	3705	Demography
	3706	History and Philosophy of Science and Medicine
	3799	Other Studies in Human Society
3800		**Behavioural and Cognitive Sciences**
	3801	Psychology
	3802	Linguistics
	3803	Cognitive Science
	3899	Other Behavioural and Cognitive Sciences
3900		**Law, Justice and Law Enforcement**
	3901	Law
	3902	Professional Development of Law Practitioners
	3903	Justice and Legal Studies
	3904	Law Enforcement
	3999	Other Law, Justice and Law Enforcement
4000		**Journalism, Librarianship and Curatorial Studies**
	4001	Journalism, Communication and Media
	4002	Librarianship

	4003	Curatorial Studies
	4099	Other Journalism, Librarianship and Curatorial Studies
4100		**The Arts**
	4101	Performing Arts
	4102	Visual Arts and Crafts
	4103	Cinema, Electronic Arts and Multimedia
	4104	Design Studies
	4199	Other Arts
4200		**Language and Culture**
	4201	Language Studies
	4202	Literature Studies
	4203	Cultural Studies
	4299	Other Language and Culture
4300		**History and Archaeology**
	4301	Historical Studies
	4302	Archaeology and Prehistory
	4399	Other History and Archaeology
4400		**Philosophy and Religion**
	4401	Philosophy
	4402	Religion and Religious Traditions
	4499	Other Philosophy and Religion

Note: Within the 139 disciplines there are a possible 898 subjects