Australian Research Council

Mapping The Nature And Extent Of Business-University Interaction In Australia

Howard Partners Pty Limited

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Foreword

In 1998-99 I chaired a Working Group of the Coordination Committee on Science and Technology (CCST) which was charged with investigating the nature of university-industry interactions. As input to the activities of the Working Group, the Australian Research Council (ARC) commissioned Howard Partners to undertake a scoping study to map the interactions using readily available information and data.

The scoping study was used to inform the Working Party's final report to the CCST (*Interactions between universities and industry***,** November 1999) but much of the information generated was not published at the time. We felt it was valuable information and subsequently invited Howard Partners to adapt the original report for wider distribution and in particular to update the material to reflect recent developments. This discussion paper is the result.

The paper examines the nature of interactions between business and university research in Australia from a business and management perspective. In many cases, of course, the benefits of research cannot be fully realised without the activities of business. This is an issue that was the focus of major initiatives in the Federal Government's recently announced Innovation Action Plan, *Backing Australia's Ability*.

Vicki Sara
Chair
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February 2001

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Preface

This paper arose from an assignment commissioned by the Australian Research Council (ARC) in 1998 on the nature and extent of university interactions in Australia. Some of the material was published in November 1999 in a report to the Coordination Committee on Science and Technology (CCST) *Interactions between universities and industry*.

The ARC invited Howard Partners to adapt the original report for publication as a discussion paper for wider distribution. As some time has elapsed since the initial work was undertaken, the material in the paper has been amended and updated. It also includes additional material and reflects the outcome of some other research work undertaken by Howard Partners over the last 12 months. Material taken up in the CCST report has been largely excluded.

In updating the paper we were aware that there is an ongoing process of policy development and implementation of new initiatives in research and development and innovation. However, in order to bring the project to a conclusion we have not canvassed developments since the end of November 2000.

The issues that are covered in the paper are contemporary and undergoing continual development, evolution and change. The purpose of the Paper is to provide a framework for thinking about some of the issues and as a basis for further discussion and consideration of policies (by government) and strategies (by business and universities).

I would like to thank my colleagues Alastair Higham, Anne Howard and Ron Johnston for their helpful comments in finalising the Paper. The contribution of Dr Mark Matthews to the earlier Report is acknowledged. Special thanks are due to Simon Sedgley of the ARC for his continuous support and encouragement. The editorial assistance of Penny Knox of the ARC is also greatly appreciated.

John Hamilton-Howard
February 2001

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Introduction

1.1 Policy context

In the current policy and economic environment, few people would argue with the proposition that success in a business environment is a matter for business, not government. Governments have a supporting, and at times catalytic role, but they will resist temptations, and at time pressures, to resort to the interventionist policies of the past. The core function of government is to commit, through various policy measures, to providing a stable macro-economy and making markets work.

In Australia, the United States and the United Kingdom, government policy is very much directed towards helping businesses compete. This does not mean picking winners and second guessing business decisions. It does mean, however, helping to build the capacity for entrepreneurship, modernising the science base and developing skills throughout the work force. In these countries, government policy is also directed towards encouraging businesses to collaborate more effectively.

In contrast to many previous reports and papers in this area that adopt a predominantly research and science policy focus, this paper looks at the nature and extent of interactions from a predominantly business perspective. This perspective also links with the substantial amount of research that has been produced recently about business innovation.

It is now well known that successful businesses emphasise internal collaboration and teamwork between corporate offices and operating units and between business units to allow new ideas to flow freely and goals to be shared rather than imposed. This is the foundation of the innovative organisation. Success in the global economy also requires an appropriate mix between competition in the market and collaboration in the development of ideas and the application of knowledge.

In this context, the role of government should be to support business in building capabilities that Australia needs to compete by:

strengthening capacity for innovation and managing risk;

- investing in the knowledge base, particularly science and technology;
- improving the skills and capabilities of the workforce by supporting training and lifting educational standards; and
- helping business make the most of information, research and technology both domestically and internationally.

1.2 The importance of "Institutions"

The importance of public and private institutions is being increasingly recognised as a critical influence in a nation's propensity to innovate. These institutions, implicit and explicit, extend beyond the efficiency of markets. They include:

- the quality of public bureaucracies;
- the ability of government and business to work collaboratively;
- the extent and nature of government expenditures on research and development (R&D);
- the governing structure of business firms;
- the effect of financial markets on the time horizons of firms;
- the technical and scientific culture of universities and their linkages to business;
- tax incentives to savings and investment versus consumption; and
- the culture of labour management relations.

In its 1997 policy paper, *Investing for Growth,* the Government identified the key elements of an effective innovation system as:

- an education system which encourages creativity and entrepreneurship;
- a research base which provides excellent basic and applied research;
- high levels of public and private R&D;
- strong linkages between business and research providers;
- effective and rapid commercialisation of successful R&D;
- businesses that are open to change and learning;
- a high rate of technology diffusion—the take-up of improved products and processes across the economy;
- effective access to new technology through good links into leading-edge international basic and applied research;
- a learning oriented workforce;
- an internationally competitive financial and venture capital market attuned to the needs of developing high technology firms; and
- a legal and regulatory framework that encourages competition and innovation.

All of these elements are present in the Australian innovation system. They do not, however, relate to each other in a systematic way. Some elements

are stronger than others, while there are also discontinuities between them. More significantly, however, institutions do not constitute the "system". The system is in fact a complex network of interactions and formal and informal relationships – including cooperation and collaboration – reflected in alliances, partnerships and joint ventures.

It is therefore useful to have a "map" of the system that identifies the elements and the relationships in the context of university-business interactions. Developing this map is the focus of this paper.

In its report *National Innovation Systems*, the Organisation for Economic Co-operation and Development (OECD, 1997) observed that technical progress is largely the result of a complex set of relationships among institutions and individuals, who produce, distribute and apply various kinds of knowledge, and thus translate the inputs into outputs with higher degrees of value-added. The links that tie them can take the form of joint research, personnel exchanges, cross patenting, co-publication, purchase of equipment and a variety of other channels. The performance of a country in innovation depends on the effectiveness of these ties in uniting the diffuse elements of a collective system of knowledge creation and use.

Pilot studies done for the OECD on national innovation systems indicate that high degrees of technical collaboration, technology diffusion and personnel mobility can improve the innovative capacity of businesses in terms of products, patents and productivity.

Current approaches to understanding the process of economic development stress the importance of links between investment in its broadest sense, including tangible and intangible assets, the ability to absorb new ideas, and national productivity growth.

The importance of generating ideas has been addressed in the recent reports of the Chief Scientist[1] and the Innovation Summit Implementation Group[2]. These reports have a strong science and technology focus. In a broader context, however, the importance of generating and developing ideas is also being addressed in the general management literature, particularly that associated with academics who consult widely to large corporations.[3]

1.3 The influence of globalisation

In 1999 it was estimated that truly global markets produce and consume about 20 percent of world output ($US6 trillion of the world's $US28

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[1] *The Chance to Change*
[2] *Innovation*: *Unlocking the Future: Final Report*
[3] See, for example, Gary Hamel, *Leading the Revolution*, published by Harvard Business School Press in 2000.

trillion Gross Domestic Product (GDP)). Over the next 30 years, as global GDP expands to an estimated $91 trillion, global markets are expected to multiply 12 fold reaching 80 percent of world output (Bryan & Fraser, 1999).

Globalisation provides the opportunity to create and satisfy profitable customers in new ways in new locations. However, Australia is a small market and some distance from large mass markets where "profitable customers" are located. Only seven of the Fortune Global 500 Companies, for example, are headquartered in Australia.

While this may be seen as a weakness, it can be developed as a strength. This is because global corporations are increasingly looking to smaller businesses and to university research centres to enhance innovative capability, flexibility and access into national markets. The way in which these relationships develop and are managed is an important issue for Australian universities and technology companies.

It is important that we understand that Australia is not the only country looking at increasing its innovative effort in a global context. For example, the US Council on Competitiveness has pointed out:

> Every company ranks the capacity to innovate – the transformation of knowledge and ideas into new products, processes and services – as a top priority. Innovative capacity plays a dominant, and probably decisive, role in determining who will prosper in the global arena. For companies, innovation creates a strategic market advantage in a fiercely competitive economic environment. For countries, the ability to leverage innovation not only to achieve national goals (improved security, health, environment) but also to increase productivity and attract investment from a global source is the key to continuous improvements in the standard of living and quality of life (1998, page 9).

Globalised corporations are moving away from the vertically integrated multinational corporation to systems of partnerships and strategic alliances. Wireless Application Protocol (WAP), for example, involves 130 alliance companies.

It is unlikely that Australia will achieve success in the global environment with a strategy that largely focuses on commercialising university research through spin-off companies in the expectation that they will become global corporations. While this strategy has been successful in a few instances it has often involved extensive government investment through a range of support programs. Taking products to market, particularly the mass markets of North America and Europe, requires substantial investment in distribution, profiling and promotion.

Participation in alliances through the value chain, on a global basis, is proving to be essential for corporate success. Investment in alliance competence is becoming a critical aspect of management development particularly for growing companies (Spekman & Isabella 2000, p. 208 ff.).

1.4 Partnerships, alliances and joint ventures

It is now recognised that a nation that can foster an infrastructure of linkages among and between firms, universities, and government gains competitive advantage through quicker information diffusion and product deployment. (US Council on Competitiveness, 1998, p.16). Companies and research organisations that can increase their ability to learn about alliances and develop systems for creating and managing them will be able to move more quickly and effectively to take advantage of new opportunities.

There are, however, some concerns:

- Government programs that are as valuable for the linkages they catalyse as for the seeding they provide are still contentious issues in public policy[4].
- The processes of patenting and licensing of university research are creating frictions at the interface of university-business relationships and potential conflicts of interest between entrepreneurial and more traditional university missions.
- University commercialisation strategies based on establishing and growing spin-off companies for exclusive development of intellectual property could lock out opportunities for wider take-up and application particularly by larger companies.
- The lack of linkages between universities and small and medium-sized enterprises (SMEs) forecloses an important channel for innovation.[5] However, effective linkages do occur through faculty membership of SME owners and use of postgraduate scholars in product development.[6]

As alliances become more central to the development and commercialisation of new technologies, capabilities in building and managing alliances have become increasingly important for firms

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[4] The Commercialising Emerging Technologies (COMET) program is valuable in this regard – as were the Commonwealth's now disbanded enterprise development schemes.

[5] Participation in Cooperative Research Centres (CRCs), for example, can be resource intensive in terms of both time and money. This matter was addressed by the Chief Scientist in his Report, *The Chance to Change*.

[6] This matter was identified in a series of case studies of innovation in food processing prepared by Howard Partners for the Department of Agriculture, Fisheries and Forestry. See http://www.affa.gov.au/docs/food/casestudy.html. The Strategic Partnerships with Industry – Research and Training (SPIRT) Scheme has also supported a number of initiatives in this sector.

developing and applying new and emerging technologies, particularly in product innovation. These capabilities include:

- skills in knowledge sharing;
- evaluating the complementarity of partners;
- creating and managing co-specialised assets;
- the ability to establish trust quickly;
- creating a vision of the collaboration;
- agreeing upon a common set of goals, metrics of success;
- a shared risk/reward agreement; and
- governance.

Few managers and scientists are prepared for a world in which the boundaries between competition and collaboration are unclear. Experience with traditional joint ventures has not prepared them for the complex world of alliances. The management of alliances is receiving a great deal of attention in the general management innovation literature[7]. This material is not, however, reflected to a significant extent in the science based innovation literature.

Major issues that have to be managed in collaborative arrangements include the following:

- cultural differences;
- business systems and accounting practices which are incompatible and have different approaches, content or definitions for some common words (for example, overhead);
- sharing/protecting intangible resources;
- regulatory regimes, including tax and transfer pricing;
- a decision making methodology that is well understood with clearly defined responsibilities commensurate with responsibilities to take action; and
- methods for assessment of commitment.

Organisations wish to have multiple relationships just as people hold equity in a range of companies.

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[7] See, for example, Doz & Hamel, *Alliance Advantage*, 1998; Harbison & Pekar, *Smart Alliances*, 1998; Lasater, *Balanced Sourcing*, 1998, Yoshino & Rangan, *Strategic Alliances*, 1994

1.5 Networks and systems of informal interaction

Notwithstanding the influence and importance of globalisation, informal interactions continue to cement relationships in a complex structure of implicit contracts and understandings. As John Kay (1966) observes, there are still things that are best done by people who find themselves in the same room. These include:

- transfer of certain aspects of knowledge and skills;
- development of trust through shared experiences and values; and
- non-verbal communication.

It is on success in creating networks that facilitate these exchanges of "tacit" knowledge that many competitive advantages in the world depend. Tacit knowledge need not be business specific. The most important such skill base lies in scientific and technical training.

Locally concentrated networks are characteristic of industrial organisations in many parts of the world. These networks allow for:

- competitive strengths to be derived from a knowledge base to which all contribute and have access; and
- a capacity of flexible structures, based on trust, to respond more rapidly to changing conditions.

Aspects of geographical interaction include science parks and industry clusters. Many of these have a specific international focus, designed to attract foreign corporations to collaborate in research and development efforts.

There is a risk, however, that as levels of interaction become more formalised, and involvement of government increases, relationships may become more structured in terms of contractual arrangements, management controls, reporting, and accountability arrangements. There is also a risk of excluding potential partners due to the cost of entry into and remaining in such relationships. While management infrastructure is important, excessive structuring and formalisation can potentially destroy important elements of knowledge transfer.

Recent thinking about Centres of Excellence for Research and Development that envisage a core of discovery research and linkages to applied research organisations and commercial partners are intended to avoid structural constraints.

1.6 Objective in mapping university-business interaction

A number of studies have been undertaken on the nature of university-business interaction in Australia. They tend to concentrate heavily on science and technology capability, but play down issues of concern in business management. Few studies look at the overall picture of relationships and interactions within a suitable and well-defined overarching framework.

Our objective in undertaking this mapping exercise has been to bring a combination of science and technology policy, business, and public administration perspectives to the project. This is intended to reflect:

- the orientation of universities towards the creation and transfer of knowledge;
- the focus of industry, and firms within industry sectors, on business and commercial issues, including long term sustainability and the management of risk; and
- the extensive network of administrative and organisational arrangements and programs that have been established to facilitate, support and stimulate university-business interaction.

This perspective, the available statistical data and literature, as well as our own understanding of the issues, suggest that there are four dimensions, or layers, of interaction that constitute a “map” of university-business interaction. The four dimensions are:

- knowledge interaction;
- business relationships;
- institutional and structural arrangements; and
- government support programs.

These dimensions are each presented in terms of a classification of interactions. Classifications are intended to provide a logical and consistent way of presenting and interpreting information. They are important not only for the purposes of organising information but also for drawing inferences about content and meaning from the way in which the information is organised.

The classifications that are presented are indicative at this stage, but they do serve to separate and differentiate types of interaction as well as providing a basis for the clarification of terminology. Further research and analysis will allow for refinement of the “layers” in the map and the relationships between them. The basis of the classification is provided in Table 1.

Table 1: Classification of university-business interactions

Knowledge interaction	***Business relationships***	***Institutional and structural arrangements***	***Spatial (geographic) interaction***	***Government support arrangements***
Strategy and planning	Corporate gifts and bequests	University schools, 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 (licensing) companies		State Government departments
Access to facilities and capability	Commercial participation	Joint venture companies		
Commercial knowledge exploitation	Commercial partnership	Professional advisory and consultancy services		
	Commercial competition	University-business interface organisations		
		Business associations		
		Networks, forums and roundtables		
		Alumni bodies		
		Personnel interchange		
		Personal networks		

Detailed information on the nature and extent of each of these dimensions of interaction is provided in Chapter 3.

1.7 The overall significance of university-business relationships

Notwithstanding the importance of Commonwealth Government Grants, Australian universities funded under the *Higher Education Funding Act* (HEFA) receive a very significant proportion of their income from other sources, including business. To illustrate, Table 2 provides summary information about the sources of funding for universities in 1997. The data has been calculated from published higher education statistics.

While the revenue proportions differ widely between universities, Table 2 points to a large contribution to revenue from 'other research grants and contracts' and from investment income. Fees and charges also contribute large amounts of revenue.

These revenue streams suggest that there are strong business relationships in universities for contract research, sponsorships, management of investments and fee for service activities, including courses and programs for business.

Table 2: Breakdown of aggregate university sector sources of funding

Funding Source	***Proportion (%)***
Commonwealth grants	53.8
HECS	14.7
State Government	1.1
Other research grants and contracts	4.7
Scholarships and prizes	0.2
Donations and bequests	1.2
Investment income	4.0
Fees and charges	14.9
Other operating revenue	6.5
Deferred income	(1.2)
Total	100.0

Source: Howard Partners calculation using data from Selected Higher Education Finance Statistics, 1997.

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Organisations and systems of interaction between universities and business

A recent assessment of science and technology management (Ganguly[8] 1999, p.33) has emphasised that important changes are taking place in the relationship between universities, research institutions and business R&D departments. In particular there has been an emergence of new forms of university-business partnerships reflected in arrangements where academics work on business R&D projects in formal and joint teams. This is replacing the traditional donor-recipient contracts and relations between academia and business.

Companies have put in place well planned access to academic centres, which are generators of knowledge, through a network of project partnerships. They see this as the only cost effective method for a firm to sustain a critical mass of leading edge R&D capability (Ganguly 1999, p.5). In Australia there are many well-established and effective arrangements between business and university centres, particularly in the manufacturing sector, that operate without government support.

The cooperative and collaborative relationships between universities, research organisations and business can be considered in terms of a spectrum that ranges from unconditional financial flows to highly structured corporate arrangements in the form of joint business ventures. This will be considered in Chapter 3.

2.1 The importance of organisation

In the current economic and business environment the concept of the individual inventor or research laboratory achieving commercial success on the basis of one activity, and without expert management, marketing and substantial ongoing financial support, is a misrepresentation of the nature of innovation. Innovation requires cooperation and collaboration within an organisation as well as with organisations external to it.

Resources and capabilities that exist alone in research and business organisations are of greater significance when seen in the context of cooperative and collaborative arrangements. These arrangements exist, in large measure in research centres and institutes – some of which receive

[8] Dr Ganguly was worldwide director of Research and Development at Unilever for seven years.

government funding – and in other forms of formal and informal interaction between government, business and the research community.

The form of collaboration and interaction between organisations is becoming increasingly important in the context of globalisation, the cost and complexity of research and development, and the importance of supply and distribution channels. The commercialisation of invention that occurs through collaboration between research organisations, research centres and businesses is of particular interest in this paper.

The resources that are required, in terms of knowledge, skills, facilities, equipment and finance mean that significant innovations are synonymous with organisations. With few exceptions, the more recent innovations and scientific developments are associated with organisations, of one form or another, rather than individuals. These organisations may be constituted as research centres within and between universities and between universities and businesses[9]. Some of these may receive support under government programs.

What is of interest, and important for this study, is the development of innovative forms of organisation built around cooperative and collaborative arrangements between the universities, publicly funded research organisations and institutes and business. Organisation forms and structures range from the formal and bureaucratic structures, typical of a government agency or corporation, through to loose associations of people working in a networked, and even "virtual" arrangement.

In Australia, the publicly funded Cooperative Research Centres are generally seen as important ways of building collaborative arrangements. There is, however, much more cooperation and collaboration that takes place through various forms and formats, and there is much that can be done to develop and promote inter-organisational cooperation and collaboration. In this area, professionals, business associations, as well as government, have important roles to play.

2.2 Defining organisation

An organisation is a collection of "productive resources" that is managed to achieve particular purposes, results or outcomes. These resources embody a range of distinctive capabilities that allow organisations to continue in existence - as well as developing and retaining competitive advantage. An organisation's resources include:

[9] The concept of the "virtual" organization is receiving a great deal of attention (and critique) in management literature.

- tangible assets such as buildings, facilities, equipment, property and patentable inventions;
- intangibles, such as brand, image, reputation and human skills;
- management capacity and capability; and
- the funds that the organisation is able to access.

It is known that the management of innovation creates important challenges in organisations. Much has been written about innovation management within organisations, including the creation of the right environment for the development and nurturing of ideas from conception through to market.[10] Importance is attached to "organic" forms of organisation that stress teamwork, collaboration and acceptance of a certain degree of uncertainty and ambiguity. These considerations are, however, equally important to relationships between organisations.

The emergence of collaborative relationships between organisations also involves an important element of management and organisation structure. Increasingly, "organisation" is being understood in a framework that is broader than the legal boundaries of a company. Contrary to some recent thinking in economics and accounting, organisation matters: efficient and effective performance requires a management infrastructure for defining and sustaining purpose, direction, roles, responsibilities and accountabilities[11].

This does not imply that organisations need to be mechanistic or bureaucratic and hierarchical: they can be built around project teams and combinations of specific competencies.

In a number of business sectors, a network of relationships with other organisations is a major criterion for success in competitive markets. These relationships cover supply, distribution and marketing and increasingly, research and development. Research and development is now extensively outsourced to specialised organisations, including universities and research centres, under various forms of alliance arrangement. Companies wish to tap into richer innovation skills that outside suppliers can offer (Quinn 1999).

Business is being conducted through complex interlocking clusters, groups and alliances that represent fully and formally developed systems of cooperation and collaboration. These "clusters" may be geographically based – or be based on a broader concept of "community of purpose".

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[10] One of the earliest, and most significant contributions in this area is by Tom Burns and G.M. Stalker, *The Management of Innovation*, first published in 1961 and republished in a revised edition by Oxford University Press in 1994.

[11] These points are well made by Peter Drucker in his most recent work, *Management Challenges for the 21st Century*.

It is also recognised that networks of relationships between firms and organisations are essential where:

- more is derived for an organisation than "going it alone";
- strategic competencies and capabilities are augmented;
- strategic flexibility is retained; and
- competencies/capabilities are not "appropriated" by a partner or collaborator.

In the context of research and development, collaborative arrangements allow for different organisational forms to co-exist, for example, the "organic" structure of a research team with the formal authority and control structures of a large corporation or a university department.

A number of large organisations have "spun out" their research departments with the specific purpose of allowing for the different organisational forms to continue and co-exist.[12] There are also situations where research and development capability has been "spun out" from university departments to create a greater focus on the market and commercial imperatives.[13]

2.3 The pressure for stronger university-business linkages

Before the 1980s, universities and businesses did not mix much. The modern concept of technology transfer, that is turning university research into commercial products and services, is comparatively recent. Traditionally, companies have relied heavily on their own research laboratories to develop technologies for commercial application. These institutions are still an important source of innovation.

The traditional perception of universities is that of teaching and "discovery research". However, universities are becoming much more involved in "problem driven" research. This development has been associated with greater collaboration with business and the development of trans- and interdisciplinary approaches to scientific inquiry. For example, it was largely business that saw the emergence of new business opportunities emerging following the insights into DNA and the silicon chip driven growth fuelled by the computer industry.

The OECD (2000, p.164) has noted that universities and business have always maintained contacts to ensure good job prospects for graduates, keep

[12] BHP provides an example, with its research labs going to Swinburne. Lucent Technologies is a "spin out" from AT&T.
[13] The Institute for Drug Technologies, which specialises in clinical trials and contract manufacture, was set up this way.

curricula up to date in some disciplines and to obtain financial and/or in kind support to reinforce and expand teaching and research capabilities beyond that which core funding would allow.

More recently, the larger research universities have strengthened these contacts into strategic alliances to consolidate their positions in innovation networks and to participate in the booming market for knowledge. Smaller and less well endowed universities are looking to transform parts of their research capability into business support units and contract research organisations (OECD 2000).

The pressures for change have occurred from both within universities and within business.

For universities, the pressures on funding that occurred from the early 1980s led to a greater awareness of the possibilities for commercial exploitation of invention through, firstly technology licensing, and more recently, spin-off companies. It has led to a greater focus on the outcomes of research.
For business, the shortening of the product development life-cycle and the competitive pressures of globalisation, meant that it had to look more broadly for new technologies. Few companies now retain in-house all of the necessary capacity and capability for innovation in their product areas. For example, Dr Joseph Miller, Chief Technology Officer at DuPont has observed:

> For most of our history, we believed that we ourselves could handle all the necessary research. Now, DuPont's dedication to collaboration extends beyond the company itself, and that is something of a change. Our relationship with the university community, for example, once focused almost entirely on recruiting its graduates. But the world of science grows increasingly complex; we are no longer capable of doing everything ourselves, nor can we afford to. So we reach out. Some of the partnerships we form are for the purpose only of acquiring data for a specific project, but more often our goal is to sponsor research that will yield new ideas . . .External networking makes the difference between success and failure when we've confronted overwhelming challenges (in Kanter et al 1997, p83-84).

Increasingly therefore, businesses are relying, through linkages with publicly funded research, on access to well trained human resources and to new scientific knowledge to complement their own R&D efforts.

There is a strong perception that linkages in Australia could be strengthened[14], but comparatively little attention is given to developing and maintaining appropriate linkage channels and business models that accommodate both research and commercial imperatives.

2.4 Commercialising new technologies

Universities and public research organisations as well as individuals and large companies, seek to commercialise technologies through further investment in product development in "spin-out" and "start-up" companies. These companies seek access to risk capital from a range of sources, including government, the venture capital market and corporate venture funds.

Commercialisation of university research has now developed into a strong theme in public policy. It is reflected in the following recent papers and reports:

- *The Virtuous Cycle: Working Together for Health and Medical Research*, Report of the Health and Medical Research Strategic Review, 1999
- *New Knowledge, New Opportunities*, a policy paper from the Minister for Education, training and Youth Affairs, 1999
- *Developing Australia's Biotechnology Future*, A Discussion Paper from the Biotechnology Task Force, 1999
- *The Chance to Change*, a Discussion Paper by the Chief Scientist, 2000
- *The Chance to Change*, Final Report by the Chief Scientist, 2000
- *Unlocking the Future*, Report of the Implementation Summit Implementation Group (ISIG), 2000

In *New Knowledge, New Opportunities*, Minister Kemp states:

> We need a more pervasive entrepreneurial culture which positively encourages the commercial development of research discoveries and effective links with the business sector, together with transparent institutional structures and management arrangements which support such a culture. We should ensure, for example, that there are not unnecessary barriers which prevent researchers from holding equity in companies, or from performing research in the private sector, while holding staff positions (2000, p.27).

[14] See, for example, the *Science and Technology Budget Statement, 2000-01.*

The Chief Scientist has reported that it is "vital that appropriate mechanisms and incentives are in place" to ensure that ideas and technologies generated by the science, engineering and technology (SET) base are converted into wealth and jobs so that the community can get the best possible return on its investment. The discussion paper states:

> This involves strengthening the links in Australia's innovation network by bringing universities and businesses closer together, and by providing researchers with the skills and incentives to take their ideas to the market – that is, encouraging commercialisation and connectivity in Australia's SET base (2000a, p.44).

Similarly, the Innovation Summit Implementation Group (ISIG) argues that:

> Maximising the outcomes of investment in public sector research will create new business opportunities, jobs and exports. However, there is a perception that public sector research in Australia is somewhat less than commercially orientated and that this needs to be addressed. Where there is a commercial orientation, there is often a lack of expertise in valuing and managing intellectual property, business planning and business management. If we do not have the skills to manage commercialisation well, we cannot expect healthy returns from our investment and efforts (2000, p.25).

The Biotechnology Australia Discussion Paper observes that strategies to commercialise biotechnology in Australia must recognise that collaboration is a feature of biotechnology research and that it involves "strategic alliances with foreign organisations with some or all of the commercialisation carried out offshore" (1999, p.28). The Paper goes on to observe:

> The time to market for a new biotechnology-based product, involving product development and regulatory approvals, can be up to ten years if a human-use pharmaceutical is involved. Firms must survive for a long period before significant revenue can be earned. Due to these costs and delays, research and commercialisation is often undertaken in collaboration with a multinational biopharmaceutical or agricultural corporation. Attraction of an international partner, negotiation of agreements and management of ongoing collaboration are, along with raising investment from domestic sources, critical management issues (p.28).

Similarly, *The Virtuous Cycle* (NHMRC, 1999) points out that collaboration between top researchers and new business enterprises has a positive effect on the enterprise's products in market, products in development and

employment growth. The report also noted a comparatively low level of involvement by Australian researchers in new business enterprises (p.136).

Notwithstanding the acknowledgement of the importance of management capacity in these reports, its significance is very often understated. Management issues receive little attention in the executive summaries of these reports and papers. Management capacity is added almost as an afterthought rather than as a key driver of the commercialisation process.

Attention in recent reports and papers has been focused on limited access to risk capital as a result of risk aversion investment strategies of superannuation fund trustees, a lack of understanding of early stage investment by asset consultants and a lack of a track record in the area by venture capital managers. Problems with the availability of risk capital have also been analysed in the recent paper sponsored by the Department of Industry, Science and Resources.[15] These are not, however, the main problems.

The reality is that in early stage investing, fund managers are investing not so much in a product, but in the capacity of a management team to create a business and bring a product to market to achieve sustainable returns. In Australia, the critical shortage is in "entrepreneurial" management capability. The combination of skills in marketing, financial structuring and the capacity to do the "deals" that are required to successfully "commercialise" a technology into a marketable product is very difficult to acquire. There are few opportunities to learn and develop skills, knowledge and capabilities in these areas in Australia.

2.5 Managing risk

Successful commercialisation of newly developed technologies involves much more than access to risk capital as some recent reports have suggested. It is the capacity to successfully manage risk, as the central component of entrepreneurial management, which is in short supply. Recent research has indicated that successful businesses have become skilled in risk reward management (Bryan, et.al, 1999). Few scientists trained in research methods can (or want to) make the transition to the practice of managing business risk. Success is often associated with alliances and other forms of business collaboration.

Large companies, with their own R&D capability, take a great deal of care in acquiring underdeveloped technologies externally. They prefer to wait until technologies are "proven" to be marketable before making investments. However, in order to tap into the potential of emerging

[15] *Benchmarking Australian Institutional Investment in Domestic Venture Capital*.

technologies, large companies are establishing relationships with university research centres and are tending to invest in a "portfolio" of small technology based firms that have been "spun out" of universities and public research organisations (Gross et al 2000, p.52).

By contrast, Australian research institutions consider Australian companies, particularly small to medium enterprises, to be reluctant to acquire research and development capability that is already available to improve product performance[16]. There is a view that managers do not understand the cost of research and development. In other words, research and development is not seen as an investment for the future but as an expense that impacts adversely on the bottom line.

Businesses are often being told by government they should recognise the benefits that a closer relationship with the science base can offer. For example:

> Appropriate networks and linkages allow businesses to access skills and knowledge needed for the establishment of new products and processes. Industry leaders can gain immeasurable benefit from being in the communication loop with scientists and engineers engaged in basic research, and from using the instruments of knowledge translation – such as venture capital – to invest strategically. This depends on a finance sector that is able to respond effectively to innovation-based investment proposals (DISR 2000b, p.1.6)

While there are opportunities, government needs to understand that investment in innovation-based proposals involves a very high degree of commercial risk. Venture capital investors invest in higher risk private companies, with the expectation of obtaining a higher than average return. For early stage companies, these expectations are set at a very high threshold.

Venture capital, as an asset class, is well suited to the information technology and communications sector, where high returns and relatively short investment time frames can be achieved. In other sectors, there is a wide variety of business models being developed that are appropriate to the technology and mechanisms for managing and sharing risk. These approaches involve new internal management practices as well as strengthening external relationships with research organisations, suppliers and distributors.

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[16] This view is pushed very strongly by Food Science Australia. Australia has substantial unused capacity in food product R&D in research institutions and universities.

2.6 Business investment in research and development

Government and business organisations have expressed concern about the relatively low levels of investment in research and development, particularly by the business sector. Australian business expenditure on research and development (BERD) ranks 19th among 25 countries identified in the annual *Science and Technology Budget Statement* (DISR 2000b, p.4.13). Expenditure is estimated to be 0.79 percent of GDP compared with an average of 1.20 percent and 2.08 percent for the United States, 1.22 percent for the United Kingdom and 1.57 percent for Germany.

These comparisons need to be seen in context and, in particular, an awareness of Australia's emergence from a "mixed economy" in the post war period through to the end of the 1970s. The rate of increase of BERD between 1984 and 1991 was 10.9 percent compared with a 25-country average of 6.9 percent. This was exceeded only by Korea, Taiwan, Singapore, Ireland and Spain. Between 1991 and 1998, the annual rate of increase in business R&D has been 10.2 percent compared with an average of 6.2 percent and exceeded only by Finland, Taiwan, Singapore, Ireland and China (DISR 2000b, p.4.13).

From a business perspective investment decisions, including decisions to invest in research and development, are made on the basis of assessment of the combination of cost, risk and return. In an increasingly global competitive environment firms are looking to strategic alliances throughout the value chain to manage cost and risk. This creates a challenge for both companies and research organisations to develop effective, business based, cooperative and collaborative arrangements to achieve mutually beneficial outcomes.

Change will involve a move away from traditional forms of business support for universities towards closer alliance relationships where substantial value is created for all participants. The role of government in facilitating the creation of new forms of alliance arrangements is an important policy issue. In particular, policies to support business R&D should be considered in parallel with other strategies to promote global competitiveness, including market access, and foreign direct investment.[17]

Public policies might also be directed towards facilitating linkages with international research organisations and businesses as a means to attract and encourage location of corporate research and development capability in Australia.

[17] On an international basis, high levels of foreign direct investment are closely associated with high levels of business R&D.

2.7 Impacts and implications

The trends in the public funding of higher education, pressures for commercialisation of university generated intellectual property, new approaches to R&D management within corporations, a changing culture of learning, and the growth in small companies in the high technology industries, has led to the emergence of new forms of research and development that require close working relationships between people located in different institutions – not all of whom need be scientists. In this context, it has been observed that:

> . . . there are formally designed interactions of university-based researchers with business people, venture capitalists, patent lawyers, production engineers, as well a research engineers located outside the university. This has invariably involved shared use of academic and industrial facilities. Under these conditions, technology is more likely to be trans disciplinary, and to be carried out by people who are able to rise above disciplinary and institutional loyalties.
>
> These and similar changes and transformations are advancing so rapidly that their impact on traditional institutions and attitudes has just begun to be understood (Ganguly 1999, p33).

Changes in the organisational arrangements are also having an impact on funding arrangements. Public funding from government programs is increasingly being supplemented and/or replaced by firms, industries and business associations representing a group of firms.

The consequence of these developments has been a new way of generating, managing and exploiting knowledge with significant implications for the science, technology and innovation infrastructure. Moreover, in an American context, but increasingly relevant to Australia:

> Because the emergence of this new way of working had not been clearly foreseen or visualised and did not quite fit the linear management models of the day, the creation of trans- and interdisciplinary science clusters, which were task or sector specific, evolved more or less by trial and error (Ganguly 1999, p.37).

Science and technology clusters represent “utilisable entities of fundamental knowledge flowing in from a critical mass of related scientific research” (Ganguly, p.98). Science clusters are often firm specific and need not be limited by geography: they are defined in terms of the interactions and relationships of scientists and their respective fields of expertise. With information technology, such clusters may reflect a combination of regional, national and international dimensions.

At the same time, however, a science and technology cluster may be seen in a geographic sense where separate institutions, in combination and

collaboration, build a critical mass of utilisable knowledge. This can be observed in areas such as molecular biology, a field of inquiry that has evolved as a result of the way questions are framed and research undertaken in immunology, genetics and cell biology across a number of organisations. It is also an area that is of intense interest to companies.

There is probably more to be done, however, in promoting collaboration and cooperation between scientists and attracting and sustaining corporate interest and involvement. Some large companies have argued that the lack of collaboration between scientists and institutions is a major disadvantage in innovation in drug discovery in Australia. The competitive process and the low rate of funding for projects have also been seen as disincentives for collaboration. Vertical collaboration between multi-disciplinary sciences is critical in drug discovery.

To develop the capability of drug development, scientists will have to work together in a multi-disciplinary approach. This is already occurring across a number of institutions – nationally and internationally. In the future, innovation in medical research will come from discoveries in genetics and identification of new targets for drug design. These opportunities will be achieved through close working relationships between geneticists, molecular biologists, chemists, pharmacologists, toxicologists and clinicians both within and between research organisations.

University-business collaborative partnerships emerged in the agriculture sector, and still have an important role in Australian agricultural research institutes. More recently, partnerships have received further impetus by the spread of venture capitalism which has "given a whole new meaning to risk taking and entrepreneurship (Ganguly 1999, p.37). Australian venture capitalists are becoming much more involved in university-business-finance partnerships in technology areas[18].

Only a few Australian venture capitalists, however, can bring international contacts and the capacity to arrange downstream deals with global corporations that yield high returns on the technology. A number of Australian university spin-out technology based companies work directly with large corporations on an alliance basis without the involvement of a venture capitalist. Many of these companies have their own venture finds.[19]

The development of linkages and alliances between business and universities has implications for traditional measures of investment in research and development. Public statistics record where research is performed – not who pays for it. Thus, an increase in university performed

[18] A recent example of such a partnership is the commercialisation progress of the Australian Photonics Cooperative Research Centre.
[19] The Macquarie University-Cisco deal is a current example.

research in collaboration with business will under-state the level of business investment in research and development.

2.8 Conclusion

An organisational perspective recognises that innovation mostly occurs in an organisational context. While individual inventors, acting alone make important contributions, the reality is that most innovation occurs in situations where there are substantial capabilities for research and development, management of resources and for understanding markets and consumer preferences. Organisations also provide the supportive infrastructure for a working environment – including the physical systems used to store and transmit intellectual material.

We take a broad view of organisations: they can be formal, in a hierarchical context, with clearly defined boundaries, or they can be informal, built around networks and alliances. Networks and alliances, based on cooperation and collaboration, are becoming increasingly important in the knowledge economy. What is of interest are the capabilities of the organisations, both formal and informal, that make up the science, technology and innovation resource base.

In the current economic development environment, it can be argued that a nation's potential depends not so much on its location and science, technology and innovation resources but on its human will, skill, energy, values and organisational capabilities, including the capacity to enter into collaborative arrangements and support the operation of networks. There are, however, divergent views about the appropriate "business models" in this increasingly important area.

3

University-business interactions: a framework

In this chapter of the paper, a detailed framework of university-business interactions is provided. It provides the basis for addressing the issues raised in Chapter 2 concerned with developing and maintaining cooperative and collaborative arrangements. These arrangements lie at the foundation of strategic alliances, partnerships and similar forms of interaction that are becoming increasingly important in a global context.

The framework provides the basis for identifying strengths and gaps in the structures of interaction and a basis for identifying where public policy action might be required.

Interactions are identified in several categories:

- Knowledge interaction
- Business interaction
- Structural interactions
- Geographical interactions
- Government support

These categories are discussed below.

3.1 Knowledge interaction

Knowledge interaction occurs across a spectrum that ranges from information transfer to knowledge enhancement via research, to access to facilities and capability through to commercial knowledge exploitation. These interactions provide the “channels” through which information and knowledge flows and provide the basis on which formal and informal relationships are developed and maintained.

The knowledge interaction relationships are summarised in Table 3.

Table 3: Knowledge Interactions

Class of Interaction	***Sub classes***	***Nature of the Interaction***
Strategy and planning	Training requirements Research requirements	Joint committees and consultations Informal meetings and consultations
Information transfers	Consulting Commercial publications Formal academic publications Informal publications Sales of data sets	Flow of information for money Sale of reports and papers Public domain books and journals Working papers and reports Sale of data sets
Skill transfer between sectors via people	University to business placements Business to university placements	Industrial, public service and ministerial office secondments Academic secondments New career move
Skill enhancement	Undergraduate training Graduate training Short courses Long term training programs	Flow of people Flow of information for money
Knowledge enhancement	Commissioned research projects Dedicated research centres and institutes	Specific projects Firm specific research centres Multi-firm-university research collaboration
Access to facilities and capability	Scientific instruments Information-knowledge communication Information archives	Use of facilities and/or instruments Use of communication networks Use of archives
Commercial knowledge exploitation	Technology transfer through licensing of intellectual property rights Spin-off companies	Transfer of intellectual property rights to an existing or new business enterprise

These interactions occur through a range of business relationships and structures. For ease of reference, knowledge based interactions are regarded as occurring through linkage “channels”. These channels are discussed below.

3.2 Business interactions

The business relationships between universities and business can also be considered in terms of a spectrum that ranges from unconditional financial flows to highly structured corporate arrangements in the form of joint business ventures. These are summarised in Table 4.

Table 4: Business Interactions

Class of Interaction	***Nature of the Interaction***
Corporate gifts and bequests	Business makes funds available as an act of "corporate citizenship". This may involve naming of a facility, Chair, building, scholarship, prize or award. A donor organisation or entity may, in time, receive an honorary degree or an academic title in recognition of continuing support. Recent changes to the capital gains tax arrangements will facilitate an increase in the flow of corporate bequests.
Corporate sponsorship	Businesses invited to contribute funds to support a teaching and research centre or institute through "membership". Grades of membership might also be offered. Business may have the option to collaborate on further research – generally not encouraged by centres that wish to supplement academic salaries. Similar to sponsorship of a cultural institution. Business benefits from its name associated with the research effort and the networking opportunities. Business has no involvement in setting directions or priorities, although may be invited to be a member of Faculty or a Board. Corporate sponsorship also involves supporting staff to undertake post-graduate research. There may be tax benefits associated with sponsorship.
Cooperation	Working to achieve a common end with a strong collective, "public good" benefit. There is a focus on creating and applying new knowledge. Participation and contribution of research students. Interaction is on a program basis. A specific entity may be established to manage the process and "own" the outcomes. Funding on a "contribution" basis. Business participates in the management of the program.
Collaboration	Working to resolve a specific problem to achieve a business outcome using and applying existing knowledge. Interaction is on a project basis. A specific entity may not be established. Business participates in the design and management of the project. Funding on the basis of an agreed budget.

Table 4: Business Interactions (continued)

Class of Interaction	***Nature of the Interaction***
Contract and consultancy	Working to achieve specific "business" ends – for a specific outcome or a process for transferring knowledge. Business specifies an outcome and pays a specific fee for service. Funding on the basis of a contract. Can relate to research and training.
Commercial Participation	University staff participate as expert advisers to business – as Board members or special advisers. Substantial benefits may be derived from having an expert "academic" as a Board member.
Commercial Partnership	University seeking to commercialise aspects of capability through joint ventures with business in the form of spin-off companies. Other areas include short courses, conferences and seminars with business sharing the risk, to make money for a faculty and/or academics. Business contributes funds through equity investment. Business may accept part or all of the risk in the venture. May be an business association involved.
Competitive Commercial	Working to achieve a financial return from a business enterprise in competition with existing businesses. Covers aspects of consultancy, continuing education, conferences and training. Universities in competition with business for the provision of products and services. Competitive neutrality a major concern. This issue is being addressed through Commonwealth pricing reviews.

These business relationships are important in addressing the institutional and structural interactions outlined in the next section

3.3 Structural interactions

University-business interaction involves a variety of structural and organisational arrangements. These structural arrangements can be classified as follows:

- formal – organisations and institutions established with the specific purpose or high priority for encouraging university-business interaction;
- facilitatory – organisations that provide an interface between universities and business; and
- informal – networks of people in a variety or organisational and institutional settings with a common interest and/or purpose.

The nature of these relationships is outlined in Table 5.

Table 5: Structural interactions

Class of Interaction	***Nature of the Interaction***
University schools and faculties	University schools and faculties interact with business through business membership on faculty and business people involved in teaching courses and programs. Businesses also support faculty research directly.
Research institutes and organisations	There is a number of research institutes established by legislation or universities as separate entities. Many of these have strong university and business linkages through membership of governing boards and in research programs.
Research centres	Research centres have emerged as a response to a need for strength and diversity in university-business interaction linked to formal university research strategies. There are between 750 and 900 research centres in the higher education system, depending on sources and definitions. Centres can by-pass University funding arrangements by drawing on business and government contracts. They provide a focus for integration of different modes of university-business interaction, for example, PhD programs, short course delivery, business training and consulting. Fifteen research centres receive ARC funding as "key research centres" and nineteen as Special Research Centres.
Cooperative Research Centres (CRCs)	Cooperative Research Centres are collaborative research and education ventures which seek to develop strategic linkages between researchers and research users, particularly business. CRCs have a focus on: • research, research training, education and commercialisation; and • basic, strategic and applied research and development. The CRC Program, which commenced in 1990, supports research with a primary focus on the natural sciences and engineering and their application, although it is recognised that the work of many CRCs will be multi-disciplinary and may involve contributions from other areas. There are currently over 60 CRCs (including the new round announced in January 2001) with formal structured arrangements with most of Australia's HEFA funded universities. They have built on existing, but less formal research linkages and have become important centres for postgraduate research.
University technology licensing (transfer) companies	Most universities in Australia have established commercial companies or business units to market and license technologies to business. An important function of these companies is to advise on and secure the intellectual property in the technology. Arrangements differ among universities from situations where all intellectual property is managed through a single technology commercialisation company to one where intellectual property is vested in individual researchers with companies providing a service on a competitive basis with other commercialisation entities.

Table 5: Structural interactions (continued)

Class of Interaction	***Nature of the Interaction***
Joint venture companies	Increasingly, universities are going beyond the licensing of intellectual property to becoming actively involved in the creation of businesses to undertake product development, manufacture and distribution. Following US experience, some universities seek to derive more income from equity injection and subsequent sale or listing rather than direct licensing of a company. These arrangements involve a high level of collaboration between universities, business, venture capitalists and other financial intermediaries. Some companies established to develop technologies in this way have received assistance under other programs (for example, R&D Start). Decisions to acquire equity in a company involved in production and distribution tend to be taken by the university rather than the university commercialisation/technology licensing company.
Professional advisory and consultancy services	Most universities in Australia have established arrangements, either through their technology transfer companies, or within schools and faculties, to provide fee for service consulting and expert advisory services to business. Many are now strong commercial entities earning substantial incomes for their tertiary institutions. These businesses are, in effect, part of the professional services sector offering services to business. The scope of services covers expert advice, research, general consulting services, product testing, continuing education and exports of commercial services. There is a group of "Guru" professors who write prolifically and consult at very senior levels in corporations and make a contribution in the form of new perspectives and ideas. They run extensive seminar and conference programs and influence the thinking of both business people and consultants. There is also a group of academic "consultants", who undertake often regular assignments outside the university commercial companies and in competition with commercially based professional services firms. Income is used to supplement academic salaries – either directly, or channelled through a commercialisation company.

Table 5: Structural interactions (continued)

Class of Interaction	***Nature of the Interaction***
University-business interface organisations	University interface organisations are not as prevalent as they are in the UK and Europe. There are two significant examples: • The Australian Institute of Nuclear Science and Engineering (AINSE) was established by the Commonwealth to provide a mechanism for access to the special facilities of Lucas Heights by universities and to provide a focus for cooperation in the nuclear science and engineering fields. • The Australian Mineral Industries Research Association Limited (AMIRA) undertakes development and management of jointly sponsored research and development in mining, coal, oil and gas industries, including technology transfer services for the benefit of member companies. It administers the Australian Coal Association Research Program for Australian Coal Research Ltd. All research and development work is contracted, principally to universities, the CSIRO and CRCs. AMIRA is a participant in five CRCs.
Business associations	Business associations play an important role in promoting policies supportive of innovation. With the recognition that innovation must come from business, industry associations are directing attention to promoting and encouraging innovation among their members. Associations are tending to focus more on policy for their members and less on pressing governments for special treatment. Most associations advocate removing impediments to competition rather than advocating protectionist policies and programs. The Australian Chamber of Commerce and Industry (ACCI), a peak council of Australian business associations, represents over 350,000 businesses nation-wide. The Australian Industry Group also has a large membership base. There are also professional associations that provide for strong university-business interaction, such as the Institution of Engineers, Medical Colleges, etc.
Business networks	Businesses establish forums to stimulate interaction between academic and business personnel. The Business/Higher Education Round Table involves the CEOs of Australia's largest companies. The Institute of Company Directors is also an important "networking" organisation. The Committee for Economic Development in Australia (CEDA) is a business-based organisation that supports research and analysis on economic issues.
Alumni bodies	Universities are using alumni associations to establish linkages with business through former students as a form of corporate donation and support.

Table 5: Structural interactions (continued)

Class of Interaction	***Nature of the Interaction***
Interchange and transfer of personnel	The movement of people from business to university appointments (and vice versa) is not widespread in Australia. Conditions of employment are significant barriers. There are specific instances of movements from academic research to senior executive positions in the public service, particularly in the health/welfare sector.
Personal networks	Personal networks of people with similar education and research training backgrounds are important for encouraging and sustaining university-business interaction. Many high technology companies maintain strong linkages, through personal association to engineering faculties.

There is a range of government programs available to support some of these arrangements. These will be addressed in more detail in section 3.6 below. An important issue to consider is the extent to which these channels can be supported and strengthened to improve the level of university-business interaction towards the objective of improving the commercial application of research and development.

3.4 Spatial (geographic) interactions

Geographic interactions between universities and business occur in a variety of forms and formats. Over the last several years there have been a number of specific initiatives taken by universities to build linkages with business through co-location and sharing of facilities. Co-location facilitates university-business interaction, but effective cooperation and collaboration will also depend on other research and business drivers.

The range of spatial interactions is identified in Table 6.

Table 6: Spatial (geographic) interaction

Class of Interaction	***Nature of the Interaction***
Industry "clusters"	Industry "clusters" of similar businesses, universities and investors are important for collaboration and cooperation in business development and growth. Clusters tend to "happen" on the basis of business decisions rather than government support and assistance.

The features of formal interaction will be addressed in more detail under the heading of government mechanisms to support cooperation and collaboration. Aspects of informal and geographic interaction are addressed below.

3.5 Variations across industry sectors

The characteristics of the innovation process vary across industry sectors. There are also differences between "science led", "product led" and "process led" innovation strategies. The following example (Table 7) is based on a discussion in *New Generation Manufacturing*.

Table 7: University-business interactions in various technology sectors

Sector	***Characteristics/enablers***
Medical Advanced materials	Partnerships, particularly with universities, are a key element of the innovation paradigm. Proximity to basic research is critical. Many executives see potential dangers in the trend towards exclusive licensing of patented university research – a concern that exclusive patenting practices could compromise the open and free exchange of basic research information – a hallmark of the strength of the university system. Companies seek and emphasise national policies that bolster their investments. The focus of the Chief Scientist's Report, *A Chance for Change*.
Computer hardware Electronics Communications	Enabling technologies and applied research are more important. Technological leadership needs to be linked with rapid product development. Staying ahead requires sustained research into breakthrough technologies, fast diffusion through partnerships and strategic alliances, availability of people trained in product realisation. Rapid deployment of competitively priced products. Emphasis is on building management and business capabilities.

Table 7: University-business interactions in various technology sectors (continued)

Sector	***Characteristics/enablers***
Packaging Transport and logistics	An integration of information technologies (sensors, databases and networks, electromechanical devices for materials handling, decision support and analysis). Industry is technology intensive, but even the most technologically advanced do little research. Rely on the existing technology base and add value through integrating, demonstrating and deploying technologies in complex systems. Companies look for proximity to the right kinds of enabling technologies, but shop globally. Principal concerns are the availability of skilled personnel (eg engineers) and the regulatory environment that limits market access.
Food processing and manufacture	Technology adaptation and application. Narrowing of profit margins and the need to pay greater attention to customer loyalty emphasise the need for new, more efficient processes. Marketing, branding and positioning are critical factors and are important for national markets.

Source: Adapted from the Next Generation Manufacturing Project

These characteristics suggest that innovation strategies should vary between industry sectors.

For example, the science intensive approaches relevant to medical and advanced materials sectors, may not be appropriate to the food industry where technology application in existing and new products, and process innovation are a high priority.

3.6 Government organisations and institutions that are involved with and/or support university-business interaction

In addition to the arrangements described above, there are also relationships between university and business mediated by government through advisory arrangements, funding and research support. The arrangements can be classified as:

- Government research advisory councils and committees;
- research funding organisations; and
- research performing organisations.

Commonwealth and State Governments have established a broad range of advisory councils and committees for the purposes of addressing, informing and advising in public policy issues (Table 8).

Table 8: Research advisory councils and committees

Arrangements	***Nature of the Interaction***
Prime Minister's Science, Engineering and Innovation Council (PMSEIC)	The Council was re-launched in December 1997 to be the Government's principal source of advice on issues in science, engineering and technology and relevant aspects of education and training. The Council meets in full session twice a year to discuss major national issues in science, engineering and technology and their contribution to the economic, environmental and social development of Australia.
Coordinating Committee on Science and Technology (CCST)	The Committee addresses major issues of cross portfolio coordination of Commonwealth science and technology activity and provides a Commonwealth administration perspective on national science and technology priority setting. It complements the work of PMSEIC through providing input, where appropriate, to the meetings of PMSEIC or its Standing Committee on matters of concern that may require a whole of government response.
Biotechnology Task Force	The Biotechnology Task Force was established within the Department of Industry, Science and Resources in September 1998 to advise the Government on strategies for the development of the Australian biotechnology sector. The Task Force consulted widely with other Commonwealth Departments and State Governments, industry, research institutions, consumer groups and other stakeholders. The Task Force was disbanded with the establishment of Biotechnology Australia in May 1999.
State councils, committees and taskforces	Most States have established councils or committees to promote innovation and the development and application of knowledge in science, engineering, biotechnology and information technology to support economic growth and employment. State Councils include: The NSW Innovation Council; The Victorian Knowledge, Innovation Science and Engineering Council; The Queensland Biotechnology Taskforce.

The Commonwealth Government has also established a number of organisations to advise on and allocate funds for investment in research and development. While the larger proportion of funds is allocated to public institutions (universities, hospitals and agricultural research institutes) a significant proportion is directed towards projects that involve significant levels of cooperation and collaboration between universities and business.

The major research funding organisations are listed in Table 9. Programs that have a specific relevance for supporting university-business interactions are identified.

Table 9: Research funding organisations

Arrangements	***Nature of the Interaction***
Australian Research Council (ARC)	The ARC advises the Government on research funding and research policy, and promotes the conduct of research and research training of the highest quality for the benefit of the Australian community. It has a special responsibility for research in the higher education sector, basic research and research training and is the only government funding agency in Australia whose role is solely to support research and research training in essentially all fields of research endeavour. Through the Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme, the ARC supports high quality research involving collaboration between higher education institutions and industry. SPIRT projects are developed in conjunction with industry partners who provide matching contributions. Commonwealth contributions under SPIRT amounted to $43.3m in 1998 and $51.3m in 1999. The Australian Post Graduate Awards (Industry) program aims to encourage high calibre postgraduate research students to undertake industry-based research under the supervision of academics and industry partners. In 1999 there were 288 new awards and 599 ongoing awards. A new postdoctoral element has been added (the Australian Postdoctoral Research Fellowship (Industry) to encourage high calibre postdoctoral researchers to undertake industry based research.
National Health and Medical Research Council (NHMRC)	The NHMRC was formed in 1936 and makes recommendations for research funding under the *National Health and Medical Research Act.* The Council Research Program encompasses the full spectrum of health and medical science. Council membership reflects business, government, professional and university involvement. The NHMRC has instigated a scheme of Health Research Partnerships to provide for the establishment of partnerships that bring together basic, clinical and population health researchers in multidisciplinary teams, working at different locations. Investigators will seek support from the NHMRC and from other partners from the health sector in applying for these grants. In 1999 the NHMRC signed a Memorandum of Understanding (MOU) with a funds management company to augment funding for NHMRC supported projects by the establishment of a proposed Medical Research Investment Fund (MRIF). The Fund has not gone ahead.

Table 9: Research funding organisations (continued)

Arrangements	***Nature of the Interaction***
Cooperative Research Centres (CRCs) Committee	The CRC Committee considers applications, makes recommendations and sets conditions for CRC funding. The Commonwealth provides between one quarter and one third of funding for the centres. Commonwealth funding for CRCs was $146.9m in 1997-98 and estimated to be $137.9m in 1998-99. Since its inception, the CRC Program has funded 83 Centres.
Industrial Research and Development Board (IR&D Board)	The IR&D Board was established in 1986 to provide advice to government on national industry based R&D strategies and priorities. The Board administers specific Commonwealth Government programs supporting industry-based innovation. Board membership reflects business, government and university involvement. The Board's statutory functions provide for independent decisions at arms length from government. The Board advises and recommends allocations and grants for projects under the R&D START program – many of which involve university-industry collaboration. Innovation and the commercialisation of research outcomes are the key factors taken into account in consideration of grant and loan applications. The Board also reviews applications for the 125 percent taxation concession for research and development and reviews applications for licenses under the Innovation Investment Fund (IIF) program.
Rural Research and Development Corporations (RDCs)	Under the *Primary Industries Research and Development Act*, individual corporations develop R&D plans with industry and other stakeholders and allocate funds for strategic R&D. These funds are derived principally from industry levies and matching Commonwealth funding. Membership of Corporation Boards is representative of business, industry and government. The RDCs were established to provide for the short-term and long-term needs of Australian industry and were not specifically designed to encourage industry/academic links. They do, nonetheless have an important role in the system of interactions. The RDCs support project research, research training (through scholarships to universities), commercialisation of technology, extension, research, travel and workshops and sponsorship of relevant industry events. Funding is provided as a result of an annual public invitation to apply and by initiating specific R&D projects (commissioned research).

In addition to these specific funding organisations, Commonwealth and State Government Departments manage a large number of specific programs to support research and development. Many of these involve supporting university-business interaction.

Australia has an extensive network of publicly funded research and development organisations that undertake research for industry on a

cooperative, collaborative and contract basis. The larger organisations are listed in Table 10.

Table 10: Publicly funded research performing organisations

Arrangements	***Nature of the Interaction***
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	The CSIRO has a responsibility to carry out scientific research to assist Australian industry and to further the interests of the Australian community and to contribute to national and international objectives and responsibilities of the Commonwealth Government. It also functions to facilitate the application and use of the results of its own or any other scientific research.
Defence Science and Technology Organisation (DSTO)	DSTO provides the core of skills in Australia's defence research and advice on the application of science and technology in meeting defence and security needs. The organisation undertakes some commercial activities and participates in a number of cooperative research centres.
Australian Nuclear Science and Technology Organisation (ANSTO)	ANSTO is responsible for maintaining and keeping safe a number of major nuclear facilities on a national facilities basis. The Organisation collaborates with universities in the Australian Institute of Nuclear Science and Engineering which conducts research, education and training in nuclear science and engineering.
Australian Geological Survey Organisation (AGSO)	AGSO is the national geological research and survey agency in Australia. It has a key role to play in helping Australia's resource based industries increase their international competitiveness, while observing the principles of sustainable development.
Australian Institute of Marine Science (AIMS)	The Institute undertakes research and development in marine science and technology and promotes its application in industry, government and eco-system management.
State Government Primary Industry Research Institutes	State Governments have established and operated a number of research organisations to perform research in areas of plant and animal production. There are, for example, 18 such institutes in Victoria. Many of these organisations rely heavily on research funding from the Rural Research and Development Corporations.
NHMRC block funded Medical Research Institutes	The six NHMRC block-funded medical research institutes are recognised internationally for their continuing contributions in a number of major areas of medical research. They collaborate extensively with industry in undertaking research through sponsorship and joint projects.

In addition to their own sources of funding from budget appropriations and reserves these organisations also receive significant levels of funding from Government research granting organisations.

3.7 Government programs and linkages

There are many government programs that can be used to support university-business interaction, although not all have that particular objective as a specific program outcome.

The programs that have been identified that support the various levels of interaction are summarised in Table 11.

Table 11: Government programs to support university-business interaction

Class of Interaction	***Government Program***
Knowledge Interaction	
Strategy and planning	Enterprise development programs
Information transfers	Technology diffusion programs
Skill transfer between sectors via people	Strategic Partnerships with Industry – Research and Training (SPIRT) Scheme
Skill enhancement	SPIRT, Key Centres of Teaching and Research
Knowledge enhancement	ISR conference support
Access to facilities and capability	ISR major facilities program, Special Research Centres
Commercial knowledge exploitation	SPIRT
Business Interactions	
Corporate gifts and bequests	Income tax concessions and deductions
Corporate Sponsorship	-
Cooperation	Cooperative Research Centres (CRCs)
Collaboration	R&D Start Program, SPIRT
Contract and consultancy	Key Centres of Teaching and Research
Commercial Participation	-
Commercial Partnership	Foreign direct investment (FDI) programs
Competitive Commercial	Commercialising Emerging Technologies (COMET) Program
Communities of practice	-
Structural Interaction	
University schools and faculties	DETYA Advanced Engineering Centres Program
Research institutes and organisations	Ad Hoc government projects
Research centres	Ad Hoc government projects
Cooperative Research Centres	CRCs
University Technology Licensing (Transfer) Companies	-
Joint venture companies	State Development Corporations
Professional advisory and consultancy services	Ad Hoc Research Projects
University-business interface organisations	-

Table 11: Government programs to support university- business interaction (continued)

Class of Interaction	***Government Program***
Business associations	Grants to associations for specific project work
Business networks	State government programs
Alumni Bodies	-
Interchange and transfer of personnel	Ad Hoc secondments and transfers
Personal networks	-
Spatial (geographic) interaction	
Technology Precincts	State and local government planning and zoning incentives
Business Incubators	BITS program
Science and Technology Parks	State Government leases – eg Australian Technology Park
	University initiatives
Industry "Clusters"	Provision of infrastructure (eg Bio 21 in Victoria)

It is of some interest that government support and assistance is not available, or directed, towards all aspects of university-business interaction. There are gaps as well as areas were substantial support is provided. The overall balance and distribution of support is an important issue for subsequent consideration and review.

3.8 Observations from the mapping exercise

The analysis of the material presented above points to a "system" of university-business interactions that is highly complex. This is not, of itself, a problem. It reflects the diverse nature of the objectives being pursued and the expectations of the parties involved. The complexity of the interactions is reflected in a number of important characteristics:

- *Diversity* – the interactions between business, universities, and research institutes takes place at a number of levels and through a broad range of facilitatory mechanisms;
- *Ambiguity* – responsibilities and accountabilities between government agencies, and between governments, are not always clearly defined and often overlap;
- *Uncertainty* – policies, programs and people frequently change and good ideas and technologies do not always get supported due to the inherent biases in submission based funding, resource constraints and limited program scope; and
- *Competition* – there is competition among institutions for public assistance and there is competition between governments and agencies for a stake in the policy agenda.

Development of policies must recognise this complexity. However, the task of innovation policy and technology should not be so much to create “order” as to ensure that important gaps do not limit or inhibit capacity to improve research and business performance.

In our view, university-business interactions should be understood in terms of processes rather than structures. In this respect, improvements should be approached on the basis of process improvement. For processes to be improved, there must be a clear view of what is wrong with, and what needs to be done to remedy, existing approaches.

Process improvement is most likely to be effective where there is a vision for the redesign effort. The vision for the redesign effort is reflected in the issues and government policy statements and the imperatives outlined in Chapter 2 of this paper.

The most important processes, in the context of this paper, are:

- the progression of innovative ideas;
- appropriate education and training using these ideas and disseminating these skills;
- the application of scientific and technical knowledge to commercial outcomes; and
- application of knowledgeable, expert and competent management.

There are other important processes relating to:

- communication, cooperation and collaboration between universities and businesses within business sectors; and
- arrangements for the development of policies and programs to support the innovation process within governments and between governments.

The strengths and weaknesses of these processes are addressed in the next chapter of this paper.

4

System strengths and weaknesses

The map of university-business interactions points to a complex framework of linkages between university, business and government.

In this Chapter we provide an assessment of the strengths and weaknesses of the processes of interaction. This assessment provides an important basis for removing barriers and designing new models to encourage more effective levels of interaction between universities and business.

4.1 Overview

From a global perspective we live in an era in which the familiar division of functions and activities between universities and business is in a state of flux. Universities in a number of countries are starting to operate in ways more traditionally associated with business enterprises.

In the last two years the Commonwealth has increased funding for research – through the mechanisms of the Australian Research Council and the National Health and Medical Research Council. The forthcoming Innovation Statement[20] is expected to add further to resources for research purposes.

With increasing reliance on revenue outside Commonwealth grants programs, universities are required to operate more on a business like basis. This involves the adoption of business approaches to management, finance, investments and the development of working relationships with other businesses. Most universities now have "corporate plans" that define "missions", identify target "markets" and specify financial and other performance targets.

University-business working relationships extend from providing specific business outcomes in return for sponsorships, through collaboration and cooperation in teaching and research, to partnerships and equity involvement in business ventures. The ability to raise external income is becoming a significant factor in academic career advancement.

Universities are also now actively managing their investment portfolios to purchase and/or redevelop property and construct facilities to encourage technology intensive businesses to locate and collaborate with their research

[20] The Innovation Statement, *Backing Australia's Ability: An Innovation Plan for the Future*, was presented by the Prime Minister in Sydney on 29 January 2001.

and development capability. Some of the arrangements that are being put in place involve complex structured finance deals with financial institutions and the sharing of risk with developers.

Universities, particularly business schools, now compete for students using sophisticated marketing techniques. They have also been tending to locate their activities in central business districts to attract students in order to compete with other universities as well as private sector business-training providers. In addition, the Australian higher education sector is now a significant exporter of education services.

Universities also are being required to compete as processes concerned with the creation of knowledge, knowledge transfer, skills enhancement and information dissemination develop in business. Corporations are becoming known for their knowledge creating capabilities and are becoming more involved in delivering education services. Developments in technology have facilitated these trends.

The progressive implementation of competition policy principles may mean that businesses will be able to apply for, and receive, research funding under programs currently directed only towards public institutions. Private universities are now eligible to receive public research funding.

4.2 Corporate relationships

As indicated in Chapter 2, most universities have embraced a commercial approach to operations and are looking to business to secure sponsorship and support for their core activities and operations either as general bequests or for specific works and programs. A number of Australian universities have established Foundations, on a United States model, to attract income from this source. Recently announced changes to the capital gains tax provisions may work towards increasing the flow of funding from corporate as well as private bequests.

While the “business like” approach has been embraced by university administrations, in their relationships with business, many smaller research centres within universities have still much to learn about working with the business. For example, firms are now looking at sponsorships, donations and participation in university activities on a “business case” basis.

The competition for business involvement and commitment is becoming more intense. As universities seek corporate funds to finance general activities, teaching and research programs, they will require increasingly business oriented management skills and capabilities. This involves development of business plans, collecting and analysing cost information, preparation of tender documents and the development of sound working arrangements with business partners.

Increasingly, university-business interaction is based on an assessment of commercial factors. For the university, this means not only recovering costs but also providing a contribution to the university "bottom line". Thus, for industry, and businesses within industry, interaction is expected to deliver value to the company. Shareholder and institutional investor expectations require that value should be delivered sooner rather than later.

An association with a university, through sponsorship, "naming rights" and the possibility of receiving a return on a purchase of intellectual property sometime in the future, for example, is rarely considered sufficient as a business case for supporting an academic endeavour.

Resolution of these issues has required universities to be more entrepreneurial, as well as business-like, in their business relationships and accept part of the risks in joint business ventures. Needless to say, some universities have adopted a very commercial approach to their business relationships. This is reflected in substantial infrastructure investments for jointly owned and operated R&D research and development facilities.

In the United States there are strong relationships between large corporations and the major research universities. In June this year MIT and Hewlett Packard launched a five-year $25 million alliance in digital information systems. The current President of Hewlett Packard, Carly Fiorina, is an alumna of MIT as was Hewlett Packard co-founder Bill Hewlett.[21] There has been a history of research alliances between the two organisations.

4.3 Cooperation

In Australia, government supported Cooperative Research Centres have developed as important organisational forms that facilitate university-business collaboration. They are collaborative research and education ventures which seek to develop strategic linkages between researchers and research users, particularly business.

Cooperative Research Centres have a focus on:

- research, research training, education and commercialisation; and
- basic, strategic and applied research and development.

The Program, which commenced in 1990, supports research with a primary focus on the natural sciences and engineering and their application. It is recognised that the work of many CRCs will be multi-disciplinary and may involve contributions from other areas.

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[21] *Tech Talk*, MIT News Office, June 7, 2000.

Each CRC grant, aside from the specific knowledge produced, contributes to the development of underlying knowledge-based capabilities. The development of these capabilities takes place via:

- human capital development (knowledge and skills embodied in people);
- physical capital development (investment in research facilities and other aspects of the physical infrastructure necessary for knowledge creation, retention and dissemination); and
- social capital development (learning associated with linkage-building based upon trust, expectations about reciprocal relationships and shared perceptions of problems).

If these underlying capabilities are not developed then the eventual public return on investment in research and research training is significantly diminished.

The innovation network that is emerging from the interaction of traditional institutions (universities, business and the CSIRO) appears to be strong in applied research and linked research training. These characteristics of interactions in the innovation network vary across industry sectors. These variations reflect differences between innovation strategies among research sectors. An indication of these differences is provided previously in Table 7 (page 34).

4.4 Collaboration

The nature of the research collaboration in Australia has developed from a situation in which an enterprising academic with a potential solution to a problem went in search of an appropriate industrial partner. Although collaboration was initiated by academia it tended to be focused on important industrial requirements – and is therefore of great use in business. This was an important characteristic of traditional manufacturing technologies. Changes in business approaches to R&D management and the impact of programs such as the Strategic Partnerships with Industry – Research and Training (SPIRT) Scheme have seen the development of much closer collaborative arrangements between universities and businesses.

Arranging access to external capability on a continuing basis is now becoming more embedded in corporate strategies. As indicated in Section 4.1 above, competitive pressures, cost, and time to market considerations mean that companies can no longer afford to develop and retain in-house all of the capability necessary for research and product development.

University initiated research collaboration sometimes involves matching a scientific/technological ‘push’ from universities with an existing, usually pressing, problem faced by a firm. Given that the problem is often pre-existing, the fact that the research collaboration stems from an academic

approach indicates there may be a communication or other blockage that prevents the firm from approaching the university rather than vice versa. Although the evidence at this stage is largely anecdotal, this would not be that out of line with experience overseas. Academics who are successful and undertaking collaborative research with industry tend to operate in an entrepreneurial manner by matching their research interests with industrial requirements. Given that this collaboration is initiated by academics its support by research councils is logical.

In addition to research commercialisation, the focus of attention in most of the studies that have been undertaken has been mainly on the medical, science and engineering based disciplines. While increasing levels of funding have been provided under Australian Research Council programs for the humanities and business, for example, through the Key Centres of Teaching and Research, the nature of university-business interaction in this area has received little attention.

Most studies reviewed for this project have focused on university-industry interaction, while citing specific examples of university-business interaction. In a practical sense, the features of “industry” relationships, focusing on a collective benefit to an industry sector, may well differ from specific “business” relationships intended to provide a specific commercial outcome. In particular, considerations of ownership of intellectual property, access to commercial material, etc, will tend to differ between industry and business concerns.

The Australian Research Council Key Centres For Teaching and Research also perform an important role in focusing research and teaching effort and building expertise and provide an important level of university-business interaction. Some centres have received substantial additional funding from industry to support cooperative ventures.

4.5 Contract arrangements

The trend for firms to allocate a growing proportion of their R&D investment to university-based projects is indicative of the growing linkages between the two sectors. Available data indicated that some Australian universities receive a very large proportion of their income from contract research. However, this income is a very small proportion of the potential R&D effort.

There are, however, some structural impediments, such as low industry R&D investment that are seen as a major impediment to university-business interaction. Many foreign owned Australian companies do not undertake research and development in Australia, and if they do the technology strategies are developed at corporate headquarters overseas. The lack of technology strategy activity in Australia in such companies can limit linkage building in Australia unless a more global stance is adopted.

The structural impediments identified are long-term policy challenges that probably produce something of a vicious circle. They limit the effectiveness of university-business research collaboration in terms of final commercial outcomes which in turn act to re-enforce these structural impediments.
It is necessary to fix these operational impediments as a pre-requisite to transforming the structural impediments. Arrangements to support R&D in industry should be assessed in terms of their impact on increasing the level of university interaction through contracts to support project development. Government programs that facilitate contract research arrangements include the 125 per cent tax concession for R&D and the R&D Start program. It is understood that some recipients of R&D Start Grants engage universities as contractors for projects funded by R&D Start. However, the IR&D Board does not often fund universities directly under the Start Program.

Pharmaceutical companies participating in the *Factor f* program have made extensive use of universities on a contract basis for their research and development effort. However, global pharmaceutical companies may withdraw research and development effort with the winding down of the program in 1999-2000.

Notwithstanding these considerations, a strategy of research contracting within universities may limit the capacity of small to medium business to access research and development capability. It may also limit the capacity of universities to commercialise technologies. Small businesses faced with working capital and liquidity constraints may be willing to share equity in collaborative ventures with universities particularly in applied research and product development.

4.6 Commercial participation and partnerships

4.6.1 Academic involvement in company management

Many eminent Australian academics are members of Boards of Australian companies, particularly those in the engineering, medical and biotechnology field. However, problems and risks associated with personal liability discourage people from taking positions as non-executive directors, particularly for early stage companies.

The extent of university-business interaction through university staff holding management positions in companies, on a part time or seconded basis is difficult to quantify. There are a number of barriers to these arrangements, including:

- personal taxation arrangements and obligations;
- payment and remuneration arrangements;
- workplace risk and indemnity;
- intellectual property issues; and

- uncertainty about who receives the financial benefit – the university or the individual.

Nonetheless, with changes in work place arrangements, and the importance of network interactions for the development and dissemination of knowledge, public policies should ensure that interchange of people between the business and university environment is made easier. Consideration should be given to extending current support programs to further facilitate mobility between universities and industry.

The “free flow” of people and ideas between universities and businesses has been identified as one of the most important aspects of the success of Silicon Valley in the development and marketing of technology products.

4.6.2 Spin-off companies

The largest proportion of university spin-off companies has been established to market and license technology rather than to develop and market a product.

Anecdotal evidence suggests that some university spin-off business concepts have put more emphasis on the ‘self evident’ technical superiority of a product, process or service than upon the commercial realities of establishing the new product or service in sustainable markets.

There is a vast body of research showing how critical ‘technology marketing’ and general marketing capabilities are in successful innovation. There are many examples of technically superior products losing out to well marketed and ‘first launched’ technically inferior products.

4.6.3 Venture backed companies

It is often claimed, justifiably, that there is a shortage of venture capital to support seed and early stage start-up companies. This applies to companies being established to commercialise research and development in Australian universities.

The Innovation Investment Fund (IIF) has supported the commercialisation of a number of early stage technology and bioscience investments. Encompass Bioinformatics, a University of Sydney “spin-off”, has been supported by IIF funds managed by Allen & Buckeridge and the Rothschild Bioscience unit.

New arrangements to come into effect for Pooled Development Funds may encourage funds to take up opportunities to invest in science based start-up companies.

4.7 “Clusters”

The significance of geographical clusters in supporting university-business relationships is receiving attention in the science and technology literature. The most celebrated technology “cluster” is Silicon Valley. It reflects the synergistic development of high technology firms through linkages between the finance sector, a strong entrepreneurial culture, corporate research laboratories and universities.

Silicon Valley and the Boston area of the United States have been observed as creating an internal dynamic that supports and mutually reinforces interaction between universities, entrepreneurial and innovative businesses and the venture capital sector and business (Saxenian, 1994).

Geographic clustering is the subject of a great deal of attention in the current industry policy environment. This is because clusters are seen as playing an important role in the global competitive environment on the basis that enduring competitive advantage is seen to lie increasingly in local things, and in particular, knowledge, relationships and motivation that distant rivals cannot match. Clusters provide a category of resources that are internal to a region, but external to any particular firm or organisation.

Clusters build depth of skill, capability and competency and an ability to respond to demands for quality, consistency and continuity. This may be referred to as critical mass. Depth might be built by organisations acting alone in a competitive situation, but it is more likely that it will be developed by organisations acting collaboratively in non-market arrangements. These arrangements involve sharing of resources through partnerships, alliances, joint ventures, etc. This issue is addressed again below.

Clusters include government institutions, universities, standard setting agencies, think tanks, vocational training providers, and trade associations that provide specialised training, education, information, research and technical support. The linkages and complementarities define boundaries across industries and institutions that are most important to competition. From an international perspective clusters tend to be identified as cities or States rather than specific precincts.

Spatial asymmetries in resources, including natural resources, skills, knowledge, and industry specific expertise have been an important dimension of location theory for some time. What is attracting current attention, in the context of thinking about the “knowledge economy”, is the idea that industry specific knowledge becomes cumulative and embedded in a particular region or area rather than a specific firm. However, this attribute can only be significant if knowledge can be created, shared and communicated uniquely within the cluster arrangement.

More significant, however, is the strong tradition of collaboration and support provided by government through universities (previously institutes of technology and agricultural colleges) to industry. This tradition continues through the many university centres.

There are no strong industry clusters in Australia, although there are concentrations of technology and bioscience companies around universities and research institutes. These include:

?? Information technology*:*
  ?? In NSW, centred in the North Sydney/Ryde area
  ?? South Australia, developing around the University of South Australia.

?? Medical and biotechnology:
  ?? Melbourne, around the University of Melbourne (Parkville) and Monash University (Clayton)
  ?? Sydney, centred on the Universities of Sydney, NSW and associated teaching hospitals
  ?? South East Queensland, centred around the University of Queensland and the Queensland University of Technology
  ?? Adelaide, centred around the Flinders Medical Centre

?? Mining and minerals technology:
  ?? Western Australia.

State and local governments and universities have been actively involved in promoting the development of industry clusters. While businesses cannot be "forced" to locate in a specific area, a combination of infrastructure support, statutory planning instruments and an institutional climate that encourages university-business collaboration are important for businesses, both national and global, to make the decision to invest.

The definition of a "cluster" raises some important issues. While it is possible to identify similar types of institutions and firms located in specific postcode areas, or precincts, this does not imply economic integration or substantial collaboration. In this respect, it is important to distinguish between clusters and "co-location".[23] Co-location does not equate with collaboration.

The economic benefits associated with clustering flow from an integration of technology development activity with commercialisation of research outcomes. Invariably, this involves the presence and commitment of a large company with its own research commitment together with product development and marketing (including market access) capability. With

[23] Co-location is often impacted by statutory land use planning, availability of land and property development considerations.

Australia's small population base, global market access is a critical success factor for Australian science, technology and innovation effort.

The geographic positioning of a large organisation, that has many suppliers and a broad base of clients and customers, as well as access to common infrastructure will generally flow through to decisions of smaller organisations to locate within close proximity. Close physical proximity reduces transaction costs and increases returns. It may increase local employment – but not necessarily impact on innovation.[24] Town planning schemes and zoning regulations may also influence co-location decisions.

Major manufacturing establishments, public hospitals and universities have always had significant "pull power" throughout Australia. The development of non-market forms of collaboration may develop within these co-location arrangements – but equally, firms may choose to collaborate with organisations that are geographically distant. Research undertaken in relation to strategic alliances and business networks suggests that organisations collaborate across substantial distances.

We would argue that co-location is often driven more by competition than collaboration. Firms may be attracted to one location because it is important for competition - in that they want access to a specific client base and skilled staff and resources[25]. Similarly, the location of research institutes in relatively close proximity does not of itself imply close collaboration in research effort. Research Institutes may be fiercely competitive in their quest for funding from limited resources.

Research institutions could gain a great deal of benefit by collaborating more intensively on a regional/metropolitan wide and national basis. A number of university departments have already begun to collaborate in their research efforts in Melbourne. Considerations relating to multiple interactions and relationships, social interaction and local culture would mean that clusters are more than precincts.

4.8 Communities of practice

Recent thinking about interactions has given attention to the scope for cooperation and collaboration through partnerships and alliances as well as developing a sense of community. These arrangements may not necessarily be concentrated in a single geographic area. What is important is an organisation's capacity to form alliances and partnerships on a regional, national and international basis to enhance capability.

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[24] Large manufacturing assembly plants are a good example. They create many jobs and opportunities for component suppliers.

[25] The location of investment and merchant banks and stockbrokers in the lower ends of George Street, Bond Street , O'Connell Street and Bligh Street in Sydney is a case in point .

With rapid advances in information transfer and global distribution systems, the concept of cluster is being overtaken by reference to “communities bounded and bonded by values”[26]. Values create an ability to share ideas easily across great distances. Communities of values have clear, strong and distinct identities that have meaning to members and distinctiveness to non-members.[27] They enhance the capacity to develop social capital - a factor that is becoming recognised as a key driver of economic growth.

Peter Senge, author of the widely acclaimed book, *The Fifth Discipline*, has commented recently that:

> The discipline of innovation is practised successfully in many domains of human affairs, notably the arts and science. Interestingly, when it is practiced effectively it is invariably done within communities, among diverse individuals who share a common purpose. Energised communities, for example, characterise most periods of innovation in the arts, such as the birth of impressionism, or modern dance, or jazz. Likewise, science at its best is an intensively collaborative undertaking; even when the collaborators are strong individuals competing with one another, their competition occurs within a larger mediating community. Likewise in business, real innovation is much more collaborative than at first appears.[28]

A number of Australian based research institutes collaborate extensively on a regional, national and international basis. A number also receive funding from international sources including the National Science Foundation. There are, however, values in the science and technology infrastructure that have a distinctive regional orientation. To the extent that it is important to retain the use of the term "cluster", it should emphasise sharing, cooperation, collaboration and community values.

4.9 Competition

Many universities have developed their commercialisation businesses into professional services companies that compete actively in the market. Increasingly, business schools are offering capability provided by students. Many business plans have been written by promising MBA candidates as an element of the program requirements. The combination of research, teaching and consulting can obtain major benefits for clients and is highly valued by many clients.

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[26] Ulrich, Dave, “Six Values for Creating Communities of Value, Not Proximity”, in Frances Hesselbein, et.al. (ed), *The Community of the Future*, p.157.
[27] Ibid, p. 159
[28] Senge, Peter, “The Practice of Innovation”, in Frances Hesselbein and Paul M Cohen, eds, *Leader to Leader*, p.67.

Commitments by universities to generate revenue from commercial endeavours, particularly in the areas of short courses based on information and skills transfer and commercial consulting, might detract from the "core business" of a university in the creation of new knowledge. There is evidence to suggest that universities are competing in these areas, through self-funding "centres" where the market is highly contested and that losses are being made when all costs are accounted for.

From a strategic point of view, it might be preferable for universities to have fewer "centres" involved in running courses and commercial consultancy and a greater concentration of commitment to centres of excellence, as in the Key Centres of Teaching and Research program, where consulting effort is directed towards the creation of new knowledge and capability as part of a research-teaching-learning relationship. This trend is apparent in the amalgamation of the University of Sydney and the University of NSW Graduate Management Schools.

4.10 University-business interface organisations

Unlike many other countries Australia does not have a comprehensive set of major university-business interface organisations that provide a buffer between the two sectors and help to facilitate university-business interactions.

These interface organisations translate university research into more commercially relevant forms of knowledge, and help to communicate industrial problems and research requirements to academia.

There are some buffers, such as the Rural Industries Research and Development Corporations, and industry research institutes in mining. However Australian industry in general is not well supported in this respect.

The Australian manufacturing sector does not appear to be well served by interface organisations. As a result, it is likely that the nature and extent of university manufacturing industry interactions have been compromised. Manufacturing industry associations have traditionally focused upon industrial relations and related issues. They have been less active than their international counterparts in developing interface capabilities.

By contrast, the mining and primary industries sectors have well functioning interface capability through mechanisms such as the Australian Mineral Industries Research Association (AMIRA) and the Rural Research and Development Corporations. Professional associations in the services sector also provide an important interface role.

Nonetheless, government statistical agencies have paid insufficient attention to the inter-face/buffer organisations relative to their importance in the innovation and training process. As a result, it is difficult to back up anecdotal information of their key role with comparative statistical information and analysis.

5

Specific issues to address

In previous chapters the complexity of the framework of university-business interaction was noted and the strengths and weaknesses of the system were described. In this Chapter attention is focused on specific issues that should be addressed to remove barriers to effective interaction and improve performance and outcomes of university-business relationships.

5.1 Policy coherence

Concern is often expressed that complex systems of public-private interaction should be simplified in order to achieve greater consistency and coherence. However, work by the OECD (1996) has raised a concern that excessive efforts to achieve policy consistency can result in a high degree of central control and a consequent loss of flexibility in the policy-making system.

The OECD research points out the following:

- Although public policy is too multi faceted for mutual consistency to be achieved in practice there are “spheres” of coherence, each with its own internal logic, reflecting a different dimension to a particular issue.
- Good policy making is less a question of avoiding contradiction than one of managing it.
- Efforts to improve systems should remain centred on the notion of coherence as a guiding principle to promote outcomes such as strategic direction and consistency.
- There is a need for:
  - strong strategic capacity at the centre of government;
  - organisational flexibility; and
  - effective information gathering and processing systems.
- If contradictory decisions are made, they must be made lucidly, deliberately and on the basis of information and analysis.

Contradictory decisions are often decisions made by government agencies acting independently – either within governments or between governments. The existence of some competition within the system should not be regarded as necessarily counter-productive. Competition can sharpen performance, increase the range of options within the system, and enhance the flexibility of the system as a whole.

On any single issue relating to university-business interaction, there are likely to be many departments, agencies, and institutions involved. The forms of interaction range from Commonwealth and State Government advisory councils and committees, research organisations, research funders, specific programs of assistance and support through to science and technology parks underwritten by consortia of universities, government and business.

Each agency and organisation has an interest stemming from its specific mission, responsibilities, goals and objectives in relation to innovation, science and technology policies and programs.[29] It is likely, therefore, that there will be differences in relation to the way in which problems are formulated, issues defined, options developed and solutions advocated. Differences in agency mission and responsibilities can give rise to barriers in effective interaction as a result of gaps and shortfalls in the scope and coverage of agency programs. For example, many Commonwealth programs are "funding programs" that allocate money on the basis of specific eligibility criteria determined in a policy context – often without a great deal of consultation with industry. Programs often address symptoms of problems rather than their causes.

In the last 12 months a number of programs have been established to tackle the issue of encouraging and supporting very early stage new technology based firms. These include the Commercialising Emerging Technologies (COMET) and Building on IT Strengths (BITS) programs. There are also State based support programs.

The current features of public policy formulation and implementation suggest that it might be difficult to broach the issue of overall improvement in the system of university-business interaction. Individual agencies will continue to develop policies and programs based on their own mission, objectives and perceptions of the problem to be addressed. It is very difficult to get a "system wide" approach that involves the participation and contribution of all agencies at the Commonwealth and State level.

One of the ways that is often proposed to achieve system wide coherence is to focus the improvement effort through structural changes – that is re-allocating and redefining the roles and responsibilities of the organisations within the system. This approach is often recommended by external reviews and inquiries. However, recommendations for improvement in policy and program performance based on structural re-alignment have not had a good track record of success in Australian public administration.[30]

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[29] The present public sector management framework, with a focus on performance and outcomes, encourages difference between agencies to be highlighted.

[30] Structural solutions have a simplicity in prospect which is not matched by simplicity in stakeholder interests and expectations of outcomes.

It was argued in Section 3 that the university-business interactions can be best understood in terms of processes rather than structures and that improvement is more likely to be achieved through process improvement rather than structural realignment. The most significant problem relates to a possible “gap” in the innovation progression process.

Process improvement will involve consideration of the following issues:

?? There must be a clear "process owner" with an individual or organisation having a well defined responsibility for advising Governments on particular issues, for example, cooperation, collaboration and commercialisation.

?? While process ownership may be clear, there is a requirement, or an obligation, to consult widely with "stakeholders" in policy development, formulation and review.

5.2 Collaboration between foreign firms and Australian universities

Australian industry is funding a growing proportion of the R&D carried out in the Australian public sector R&D system, and draws upon skilled R&D personnel and research findings produced by the public sector R&D system. The competitiveness of Australian industry rests to a significant extent upon the distinctive competencies and capabilities of the Australian public sector R&D system, viewed from a global perspective, and also upon the willingness and capacity of public sector researchers to work in partnership with Australian and overseas corporations.

As the global economy becomes more integrated it is important to consider each country’s role in the emerging global science and technology system. Comparative advantage in the global system is created by investment in new technical knowledge that is both distinctive and available for commercial exploitation. Comparative advantage rests only indirectly upon natural resource endowments.

Decisions over investments in the creation of new technical knowledge take place on an international scale. In other words, the comparative advantage of each country is influenced by investment decisions in a number of other countries. Policy towards industry and innovation that neglects this international dimension overlooks the single most important factor that determines competitiveness.

In a global context, Australia’s national public sector science, technology and industrial R&D system is becoming increasingly fragile because:

?? There is a high level of overseas ownership of Australian industry. This means that decisions made overseas as part of global technology strategies can have a major impact upon Australia’s innovative capacity.

?? The small scale of the public sector R&D system means that R&D capacity is easily distorted by decisions made in a few organisations, for the benefit of those organisations.

?? The tendency of foreign owned corporations to undertake the "R" component of R&D close to global headquarters and devolve the "D" component to regional locations on an internal corporate "bidding" and business case basis.

?? The scale and scope of technical knowledge is now so vast that the Australian system will only be able to develop world class capabilities in a limited number of areas that are relevant to national industry development – there is a need to prioritise, develop action agendas and allocate resources accordingly.

The factors driving foreign direct investment (FDI) flows and their implications for research and development investment are broadly as follows[31]:

?? Clustering of business activities in locations that deliver long term competitive advantage – greater emphasis is placed on locations that develop, support and promote the supply of necessary "hard" and "soft" infrastructure for clusters of related business activity.

?? Development of "knowledge industries" – an intensification of competition in the global environment is placing increased emphasis on the availability of innovation, information and knowledge based resources.

?? International sourcing of supply inputs – business cluster development, specialisation and demonstration of locational advantage is becoming increasingly important in attracting investment activity.

?? Requirements for increased skill and flexibility of labour – industry has a requirement for labour forces to be multi-skilled, customer focused, entrepreneurial and capable of using "relationship" tools.

?? Development of regional trading blocks – international trade and investment trends have exposed domestic businesses to increased competition which requires a rapid response to a regionally competitive environment.

The competition among nations for foreign direct investment is intense. There is now awareness that in order to attract the maximum amount of investment, governments need to focus on the same factors that firms see as important to achieving their own objectives.

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[31] This analysis is based on research undertaken in the Coopers & Lybrand Policy and Economics Group in 1997 and published as *Investment Attraction Policies: A Briefing Paper*, Sydney, 1997.

Up until recently, Australia has not put much effort into attracting foreign firms on the basis of university capabilities and a willingness to participate in collaborative research and development arrangements. Foreign direct investment strategies adopted by Australian governments have been focused on attracting investment in manufacturing capacity, sometimes with generous incentives, to boost employment.

Universities, supported by State Governments and the finance sector, through their technology park and infrastructure investment initiatives have been active in promoting research and development capability in collaborative ventures with overseas corporations. The Queensland and Victorian governments have been particularly active in this area and initiatives are reflected in specific science and technology strategies.

The involvement and interaction of Commonwealth programs in the area of attracting foreign investment to support university-business R&D collaboration is by no means clear. The *Invest Australia* promotional material does not play up Australia's R&D capability while some Commonwealth university-business linkage programs do not encourage the involvement of overseas partners.

5.3 Capital market imperfections

Raising capital to finance the growth of new technology-based firms is a major problem in Australia. From a business perspective, the following factors influence the attractiveness of an investment proposition:

?? the expected return on the funds invested.

?? the risks involved – financial, economic, business and ways of minimising/eliminating risk;

?? the liquidity of the investment;

?? the ability to know the "value" of the investment on a periodic basis; and

?? the investment "climate" – regulatory barriers, community interest and support.

Uncertain returns, high risks, limited liquidity and difficulties in ascertaining the value of an investment on a regular "market to market basis" makes investment in technology based companies unattractive for major funds providers such as superannuation funds. There are now a number of "second boards" that provide greater liquidity in the small capital sector. These do not focus specifically on technology, however. The lack of an equities market for early stage technology based stocks (unlike the mining sector) makes raising capital particularly difficult.

There is no shortage of venture capital in Australia. However, the available funds are targeted at the early and late expansion and management buy-out end of the company development life-cycle. There is a shortage of equity funding at the seed and very early stages of company development, particularly for research-intensive high technology businesses.

For these reasons, a number of universities have taken an initiative and established funds for early stage and "seed" finance[32]. Seed funds endeavour to prepare deals for the formal venture capital sector – which does not tend to invest in technology firms until after the "proof of concept" stage and the marketability has been established. Funding for the early stage tends to come from "business angels", specialised venture capital funds (such as Pooled Development Funds) and corporate venture funds.

Unlike the United States, Australia does not have an extensive corporate venturing sector. The Telstra Development Fund, which invested $12 million in 70 companies over a 10-year period was wound up in the early 1990s.

Universities have a continuing and ongoing role in providing finance to support the development of technology licensing companies and take early stage equity in promising technology companies. There are now a number of instances where technology parks have assisted in the commercialisation process by strengthening linkages between universities and businesses. This occurs where parks are either within university campuses or very close by. The establishment of the Innovation Investment Fund (IIF), COMET and the BITS programs has facilitated access to capital for new technology based firms.

5.4 The significance of "social capital" in university-business interaction

Social capital 'refers to features of social organisation, such as networks, norms, and trust, that facilitate co-ordination and co-operation for mutual benefit' (Putnam, 1993 cited in Fountain, 1998, p.87). Social capital can be thought of as the 'glue' that allows physical capital and human capital to work together effectively. The World Bank has recently been exploring the concept of social capital as a contribution to development policy.

Without adequate investment in social capital existing physical capital and human capital can be insufficiently exploited because there is insufficient trust and shared expectations to overcome the inherent risks in knowledge-based interactions.

[32] The "Uniseed" fund is a recent example.

Co-operative and collaborative research provides a good example of this. Such interactions will tend to fail irrespective of the scope and severity of the contractual and institutional mechanisms used if there is insufficient trust between the partners. Trust and shared expectations overcomes the inevitable problems that will be encountered in such collaboration.

The social capital concept is important for building strength in university-business cooperative and collaborative arrangements. It highlights the importance of building business models that emphasise trust building and play down rigid eligibility criteria for government support.

There will always be a tension between formal contract arrangements and the need to give more recognition to the beneficial effects of the informal linkages that also build up social capital. This tension is inevitable given the need for accountability in the use of government funds and how it can be resolved more effectively is still an open question.

6

Future directions

The desired state of university-business interaction should recognise the importance of these relationships in the national innovation system and should reflect relationships that:

?? promote a shared understanding of the contribution of universities and business enterprises to economic and social development;

?? encourage cooperation and collaboration in the creation of knowledge and the transfer of skills;

?? facilitate the movement of people between the two sectors for short and extended periods;

?? encourage partnerships in the commercialisation of research outcomes;

?? acknowledge the importance of flexible networks and informal interactions between university personnel, business people and government officers; and

?? acknowledge the needs of different industry sectors through the development of relevant and appropriate business models and frameworks.

Our view is that the system, while complex in terms of the nature of government involvement and the range of government programs, is basically working well. Complexity is not of itself a problem; it only becomes a problem when policies, activities and actions are in conflict, or working in opposite directions.

The development of business relationships between universities and industry is often best undertaken in a commercial environment – without the involvement of government. Government has a role, however, to ensure that barriers are removed and that the results of non-market driven research allocations are available to industry as is the case in the United States and other countries with well-developed industrial R&D capability.

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