Enabling the Virtuous Cycle

Identifying and Removing Barriers to Entrepreneurial Activity by Health and Medical Researchers in the Higher Education Sector

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Executive Summary

This study addresses the Wills Review's finding that there may be institutional barriers to the involvement of university researchers in new business enterprises, specifically in relation to holding equity, directorships and moving between academia and industry. Such barriers generally appear to be less of an issue in universities than for government research organisations.

The study's main conclusion is that in general, the policies and procedures in universities do not constitute major barriers to researcher involvement in research commercialisation:

- while holding equity is still relatively rare, there are few if any formal prescriptions against it;
- the holding of Directorships generally requires the approval of the Vice-Chancellor, but is normally granted but policies do not address the specific situation of start-up companies;
- there is little explicit consideration of mobility between academia and industry to support research commercialisation, though general policies permit this;
- the financial incentives for commercialisation activities largely rest in the prescribed royalty return to the inventor.

However there are significant variations in the practice of research commercialisation, leading to serious impediments arising from *business process inefficiencies* in the way in which research commercialisation arrangements operate. A generic business process framework has been developed to provide a basis for universities to analyse their performance, and develop more appropriate approaches.

These business process inefficiencies can, to a large extent, be attributed to the relatively recent growth of research commercialisation activity in Australian universities – in other words to a lack of cumulative experience in handling these complex processes. As learning increases, particularly in launching start-up companies, the business process efficiency can be expected to increase, thus adding to the virtuous cycle sought in the Wills Review recommendations.

However, this study has revealed that the natural process of learning-by-doing is severely impeded by shortages of funding for 'proof-of-principle' and for subsequent investments that produce commercially viable propositions.

The government's announcement of the Biotechnology Innovation Fund specifically targeting the proof-of-principle funding problem in the bio-medical area is therefore an important step forward in enabling the virtuous cycle. The question is whether it is sufficient to generate the necessary changes.

Some of the leading research-based Australian universities are helping to define a *new paradigm* for research commercialisation that explicitly recognises Australia's unique combination of an advanced basic research capability and a weak industrial capability to translate these options into commercial success.

Key elements of this new approach include:

- a much greater emphasis on growing start-up opportunities;
- decentralisation of IP scanning processes;
- transfer of ownership from institution to individual;
- abolition of monopoly of university commercial arms;
- direct equity investment by universities; and
- selection and pursuit of strategic commercialisation areas.

This response to a structural disadvantage - in the form of a relatively weak industrial base and consequent limits to commercial awareness in academia - may turn out to be highly beneficial for research commercialisation in Australia.

The weak domestic industrial base makes it relatively difficult, or of limited financial value, to commercialise research via licensing. This helps to focus interest on new business start-ups, which in turn, helps to address the underlying weakness in the industrial base by creating a cohort of young science-based firms able to interact far more effectively with the science base – the virtuous cycle in action.

1.
Introduction

Policy Context

The development of science and information-based industries is a long established, and increasingly important, driver of economic growth and job creation. This type of industrial development requires effective public sector-private sector technology transfer, and associated enabling linkages, that translate academic research into commercial outcomes.

This translation of research into commercial outcomes can create a *virtuous cycle* involving universities, industry and government. This virtuous cycle is created by a mutually reinforcing process in which public sector investment in research is leveraged by industry through technology transfer and research commercialisation, leading to export growth, job creation and increased tax revenues for investment in key research areas - so reinforcing the nation's distinctive technological capabilities.

The creation of such a virtuous cycle was a major policy objective of the Health and Medical Research Strategic Review - the 'Wills Review' conducted in 1998 (Wills, 1998). Health and medical research is an area in which Australia performs relatively well in research terms and is also an area of growing economic importance globally due to the combination of advances in bio-science (such as genomics) and demographic trends. The opportunity therefore exists to create this type of virtuous cycle in Australia.

The Problem

In order for this opportunity to be exploited it is necessary to identify and remove those barriers to technology transfer and research commercialisation that restrict the operation of this virtuous cycle. Whilst some of the impediments to creating a virtuous cycle are structural, and cannot be addressed directly through specific policy measures, other barriers are more easily dealt with. The Wills Review discussed a number of those barriers and they will not be repeated here.

One type of barrier noted in the Wills Review were the institutional policies and procedures in research performing organisations that limit entrepreneurial activity by researchers. The Wills Review noted that restrictions on researchers' ability to hold equity and directorships in enterprises resulting from their research could be a barrier to research commercialisation, as could barriers to personnel movements between academia and industry.

It was observed that these institutional barriers may be a particular problem in government research organisations and hospitals, which placed researchers in these sectors at a disadvantage relative to their peers in universities and institutes. The Wills Review noted that the committee had been made aware of several cases in which such barriers existed, and illustrated this with the case of Biota.[1]

The Commonwealth Departments of Education, Training and Youth Affairs (DETYA) and Health and Aged Care (DHAC) were subsequently tasked with investigating the existence and impact of such barriers. This Evaluation and Investigations Program study was commissioned in order to assist DETYA and DHAC to respond to this request. Additional funding was subsequently obtained from the Department of Industry, Science and Resources (ISR).

Although this type of institutional barrier to entrepreneurial activity was noted to be a greater problem for researchers in government laboratories and hospitals, and less of a problem for university researchers, there is still a case for investigating this issue in the higher education sector.

This is because: (a) there is a lack of comprehensive information on the issue, and; (b) universities perform a much larger amount of the nation's health and medical research than is performed in government research organisations and hospitals.

With respect to the sectoral distribution of medical and health sciences R&D Commonwealth government organisations perform 2.5% of total R&D, state government organisations 16.9% and the higher education sector 50%[2].

An indication of research outcomes from this R&D *to industry* can be obtained by considering the academic papers cited in US patents held by Australian private entities (a measure of industry-science base inter-dependence). Australian government research organisations account for 19.4% of the academic papers cited by US patents in the biomedical area held by Australian private entities, and Australian universities 42.3% (Narin, et al, 2000).

The proportional differences between R&D expenditure levels and these patent citations probably reflects the greater emphasis on applied research in government laboratories, often associated with contract and collaborative research arrangements. These figures are discussed in greater detail in this report.

Due to the concentration of health and medical research in universities, the *overall* impact of institutional barriers in universities on national technological capabilities in the health and medical area may be greater than that of the relatively higher barriers in government research organisations.

[1] Researchers in a government laboratory were prevented from receiving the same financial reward in the form of stock options that research collaborators in a non-government laboratory were able to receive.

[2] ABS 8112.0 1996-97 'All Sector Summary', page 15. The business sector performs 18.1% and the private non-profit sector 12.4% of the national R&D effort in medical and health sciences.

Nature of this Study

The problem is therefore to identify the nature and extent of institutional barriers to research commercialisation in Australian universities and, in so doing, provide information that will allow DETYA, DHAC, ISR and the Wills Review Implementation Committee to explore possible solutions to these problems.

To this end, this study has involved both research on the nature and extent of institutional and other barriers to research commercialisation in the health and medical areas and research on international practices and arrangements for handling technology transfer and research commercialisation. The specific terms of reference for the study can be found in appendix A.

This study differs from many previous studies of research commercialisation (covering a number of research fields) in that it has collected *both* anecdotal views obtained via interviews and a larger statistical sample of views obtained via an on-line survey form. These two methods were employed because of the need to capture the views of senior university staff, and other well informed people, *and* of the researchers who face these problems in their day-to-day activities.

Methodology Used in the Study

There have been a number of studies of the research commercialisation process in Australian universities over recent years. This study has attempted to make a significant contribution to this body of understanding by virtue of adopting a strong *analytical approach* combined with a *balanced* empirical investigation involving semi-structured interviews and a formal survey.

The specific aspects of the methodology are summarised below.

An Analytical Approach

The emphasis has been on distinguishing between significant and non-significant variations in the arrangements for handling research commercialisation between different universities. A *business process* model based upon identifying generic stages and decision-points in the commercialisation process is used to draw these distinctions. This framework is augmented by considering the nature and significance of *learning-by-doing* (experiential) effects, and of the different *national circumstances* that impact upon research commercialisation effectiveness.

Balanced Empirical Investigation

Extended, semi-structured, face-to-face and telephone interviews were conducted with more than 40 senior respondents (Appendix F) capable of providing an informed view of the state of, and structural constraints on the commercialisation of university research in Australia. (Appendix G)

Interview-derived and survey-derived information were compared in order to calibrate the views expressed by senior university staff, university researchers, and the views of other informed observers about the commercialisation of university research.

Researchers do not necessarily share the same views of a university's effectiveness in handling research commercialisation as the senior university staff who set university policies and procedures. Such differences in views are the natural consequence of differences in motives, knowledge and experience.

Commercialisation effectiveness is influenced by the nature and extent of this 'perception gap'. It is therefore important to capture information on this gap. The analytical framework used is designed to help to draw policy conclusions about the implications of any such perception gap.

The study has dealt with this issue by combining the results obtained from semi-structured interviews with the data obtained from a structured on-line submission process linked to a specially created web site:
http://aamcdb.anu.edu.au/policyintelligence/p1.html
This contained background information on the study and links to relevant material both within Australia and overseas. We also sought unstructured submissions expressing views on the effectiveness of university research commercialisation arrangements.

The on-line survey form on the web site contained four components designed to capture information on:

- the respondent;
- the extent of their experience in research commercialisation;
- the appropriateness of a range of different research commercialisation avenues and to assess whether current impediments to research commercialisation affect the preferred commercialisation avenues;
- the relative importance of key impediments to research commercialisation.

Other aspects of the balanced investigation were an assessment of practices in a sample of leading overseas universities, carried out largely by accessing and analysing the policies and procedures posted to their web sites, backed up by the results of a literature review. In addition, a number of comparative and national reports on research commercialisation overseas were identified.

The study also involved carrying out four in-depth case studies of the arrangements for handling research commercialisation in Australian universities. (the Universities of Melbourne, Queensland, Sydney and Curtin University of Technology).

The Australian and the overseas case studies were designed to inform *both* the collation of factual information on university policies and procedures and the *analytical framework* for analysing this information.

The use of this balanced analytical approach has allowed us to generate new information on the nature and extent of the barriers to research commercialisation in the health and medical area and to suggest an appropriate policy framework for moving forward in Australia.

2.
Issues for Consideration

The following background issues require consideration in a study of institutional barriers to research commercialisation.

Technology Transfer, Research Commercialisation and the Public Interest

The term 'technology transfer' is heavily used in the US to refer to the process via which university and federal laboratory research results and capabilities are transferred to the business sector. The term 'research commercialisation' tends to be used in Australia. The difference between these two terms is, however, more than a choice of terminology. Technology transfer is a more generic term that covers transfers that do not involve commercial gains to the transferor. Research commercialisation is more specific and relates to situations in which there is a commercial gain to the transferor.

One reason why the elite US universities refer to *technology transfer* is that their strategies are based upon an over-arching *public interest* motivation. Technology transfers are not, in the first instance carried out for direct financial gain to the university, but are carried out to meet the institution's *public interest* obligations. As a 1998 mission of Vice-Chancellors and Principals of the Universities from the United Kingdom observed in a report on a study trip to the US:

> We were struck by the way US universities (including those with strong income streams) saw their work in technology transfer primarily as a contribution to the public interest or civic role of the university, rather than to the generation of income. In this respect technology transfer is seen as part of a broader commitment to incentives staff and to knowledge transfer, in which the production of trained minds is a crucial output. These universities have well developed strategies for links with business...Income was welcome and desirable, but it was not seen as the sole or a sufficient measure of effective technology transfer policy.(CVCP, 1999)

These public interest obligations allow universities to secure a not-for-profit tax status and to focus on core research and teaching activities. Many of the elite universities are private bodies; some such as MIT were established with direct industry support explicitly in order to provide the sort of teaching and research required by industry.[3]

In the elite element of the US system the availability of business sector funding, through various channels, and high student enrolment fees, lead to a very different

[3] US universities were originally modelled on the German system. Industrial dissatisfaction with the skills and unsuitable 'professorial' aspirations of their graduate intake eventually led to the business sector intervening in the higher education sector in the early C19 and establishing private colleges and a private-sector operated university entrance examination system that is still used today.

financial climate in which a public interest-driven emphasis on technology transfer is an attractive option. The financial gain to these universities is *indirect* and manifested in large corporate gifts, endowments and high levels of alumni contributions. This is a model that the elite British universities have been seeking to emulate over the last two decades - though with varying success.

By comparison, the trend in other countries such as the United Kingdom in which universities are far more dependent upon government funding sees revenue from commercial activities to being used to compensate for cutbacks in public sector funding.

This structural difference between US and Australian universities must be born in mind when discussing international best practice in technology transfer and research commercialisation. *It is not appropriate to recommend that Australian universities emulate the policies and procedures supporting research commercialisation used in the elite US universities (many of which are private) without considering the impact of these different structural circumstances on these policies and procedures.*

The Balance of Scientific and Technological Capabilities between Universities and Industry

Another, related, structural factor involved in drawing lessons from overseas is the impact of scientific and technological capability imbalances between the public and private sectors, and between universities and business firms in particular. The greater these imbalances the more difficult it is to carry out technology transfer and research commercialisation, particularly in terms of the exploratory cross-sectoral research that can help to close cultural and experiential gaps between university and business sector researchers.

Expenditure on Research and Experimental Development

Inter-sectoral variations in the type of R&D performed provide an input measure that helps us to understand how scientific and technological capabilities differ across sectors. Australia's official statistics are amongst the best in the world, particularly in the level of detail available. It is therefore possible to put together profiles of R&D expenditure in the health and medical area as a whole, and for sub-sets of this expenditure.

Official R&D statistics are classified by 'field of research' (FOR) and by 'socio-economic objectives' (SOE). FOR classified data tell us about the scientific fields in which researchers are active. SEO classified data tell us what the intended end uses of the research are

For our purposes SEO classified data provides the most accurate picture of Australia's health and medical R&D expenditure. Detailed breakdowns of Health and Medical R&D for 1996-97 as classified by SEO can be found in Appendix B.[4]

[4] It will be possible to construct an updated profile of health and medical R&D on July 24th 2000 when the remaining sectoral R&D reports for 1998 are published.

The following table shows an overview of the national health and medical R&D effort by performing sector and by type of R&D in millions of dollars. This is followed by a table showing the percentage breakdown of this R&D by performing sector and by type of R&D.[5] These inter-sectoral variations in the type of R&D performed are more easily grasped by considering the graph in Figure 1 - in which pure basic research and strategic basic research have been combined.[6]

Table 1: Total Health and Medical R&D in Australia by Performing Sector and Type of R&D, 1996-97

$m Current Prices	All health and Medical Research					
	Higher Education	Private Non Profit	State Research Organisations	Comm Govt. Research Organisations	Business Sector	Total
Pure Basic	62.52	32.44	30.70	1.19	0.59	127.46
Strategic Basic	122.03	46.59	52.06	9.92	5.50	236.10
Applied	199.76	35.18	81.81	9.58	31.60	357.94
Exp. Dev.	29.14	14.52	15.02	1.41	66.30	126.39
Total	413.46	128.73	179.59	22.11	104.00	847.88

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

Table 2: Percentage breakdown of total health and medical R&D in Australia by sector and type of R&D, 1996-97

Percent of total	All health and Medical Research					
	Higher Education	Private Non Profit	State Res Orgs	Comm Gov Res Orgs	Business	Total
Pure Basic	7.37	3.83	3.62	0.14	0.07	15.03
Strategic basic	14.39	5.49	6.14	1.17	0.65	27.85
Applied	23.56	4.15	9.65	1.13	3.73	42.22
Exp Dev	3.44	1.71	1.77	0.17	7.82	14.91
Total	48.76	15.18	21.18	2.61	12.27	100.00

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

[5] These figures do not relate exactly to 'field of research' classified R&D because the latter includes research that has other end-uses than human health.

[6] Many researchers are unclear about the practical distinction between these two types of R&D when they complete the ABS's R&D Expenditure Survey forms.

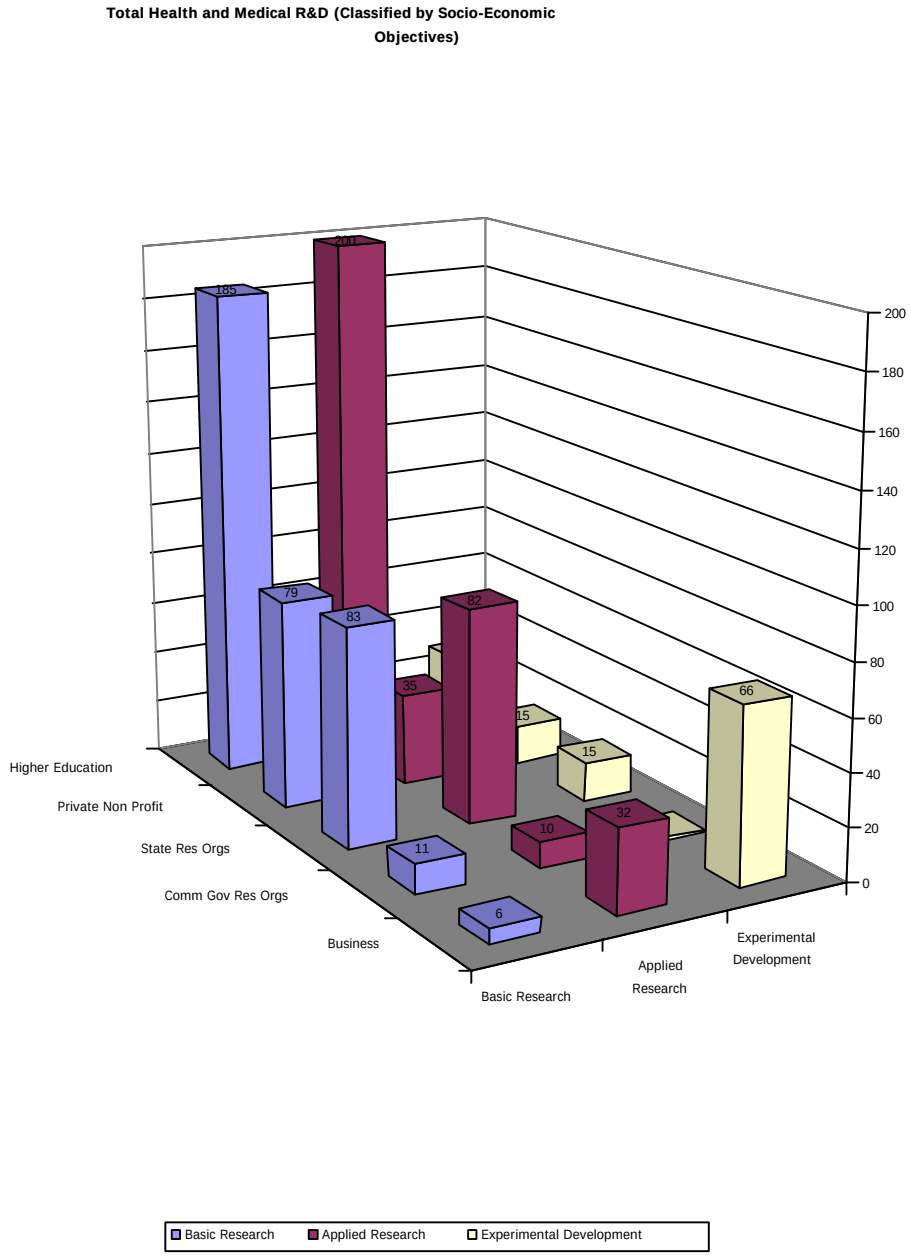


Figure 1: Health and Medical R&D in Australia by Performing Sector and Type of R&D

The dominance of the higher education sector in health and medical R&D is clear, as is the significant role played by the state government and private non-profit sectors. [7]

What also stands out, however, is the relatively low level of business sector R&D expenditure, particularly in basic and applied research. The levels of expenditure on experimental development are of critical importance because they cover the activities required to translate laboratory findings into real applications in he form of drugs, instruments and materials.

[7] This is a characteristic specific to health and medical R&D, mainly due to the high level of charitable donations made for health and medical research and the role of stage governments in funding public hospitals.

For example, clinical trials undertaken to determine the efficacy of a newly developed drug are included as experimental development. However, if the trial is to obtain approval for the use in Australia of a drug already approved overseas, then it will not be considered as part of R&D.[8]

In general terms basic research generates knowledge of fundamental properties, applied research translates this fundamental understanding into options for possible exploitation and experimental development determines which of these options are practically and commercially viable. The processes involved in experimental development are usually far more costly than the basic and applied research that 'feeds' these processes. It follows that levels of experimental development activity are a key indicator of the extent to which there is investment in attempting to exploit the options generated via basic and applied research.

These R&D expenditure figures indicate that levels of experimental development expenditure are low compared to levels of basic and applied research expenditure in all R&D performing sectors..

Appendix B contains more detailed data on health and medical R&D.

The Role of 'Learning-by-Doing' in Building the Virtuous Cycle

Research commercialisation is a risky process. As such, cumulative experience (learning-by-doing) tends to lead to an improved capacity to appraise and manage these risks.

Accepting that the research commercialisation process is strongly influenced by learning-by-doing, any institutional impediments to moving along this learning curve can potentially have dramatic long-term consequences for the aggregate efficiency of research commercialisation activity. This learning effect does not just apply to individual knowledge and skills – there is also the ‘positive externality’ associated with general flows of information and transfers of knowledge between individuals that collectively decreases technical and business risks. Indeed, the existence of these positive externalities is a major reason for the success of industrial clusters such as Silicon Valley.

Considering the specific issues addressed in this study - commercialising university research in the heath and medical area - cumulative experience affects the capacity of researchers to:

- appraise technical and business risks;
- develop strategies and tactics for mitigating these risks;
- execute these plans competently.

[8] Advice on interpreting R&D data obtained from the Australian Bureau of Statistics. Due the 'grey' areas in the relationship between clinical trials and the standard international OECD/'Frascati' definitions of R&D activities revised classification guidelines are currently being drawn up.

This cumulative experience is the product of individual experience, collective experience *and its dissemination*. It is for this reason that the involvement of individuals with previous commercialisation experience can significantly affect the risks faced in the new business venture.

The commercialisation process can, at the highest analytical level, be treated as the process of: (a) estimating the probability distribution over a range of returns on investment (from negative to positive), and; (b) shifting this probability distribution into a more favourable region.

Many new businesses fail because the risks are poorly estimated and, consequently, insufficient attention is paid to 'engineering' a more attractive cost-risk-return relationship. The 'innovation progression gap' can be treated, partly, as the combined effect of poor capabilities to estimate cost-risk-return relationships and to shift these relationships into more favourable regions.[9]

This probabilistic risk-return framework provides a useful tool for analysing research commercialisation problems because it reflects commercial realities (and the perspective of the finance sector). It also makes clear to the research community the analytical challenges that lie above the detailed legal, regulatory and business doctrine issues encountered in research commercialisation.

This perspective is compatible with *business process*-based approaches – examining the research commercialisation problem partly as a problem of the waiting periods, 're-work' cycles[10] and other factors that influence the time and cost involved in making decisions concerning research commercialisation. As experience of handling research commercialisation grows the business process efficiency in handling this process will also tend to improve.

In this study, the learning-by-doing perspective, grounded on the capacity to appraise and modify cost-risk-return relationships, has been treated as a *hypothesis* about the most appropriate means of explaining both the nature and extent of impediments to research commercialisation and the policy implications of these impediments. As a result of adopting this analytical approach, the study has the potential to contribute to our understanding of research commercialisation behaviour both on a more generic level than the health and medical area per se, and as a longer-term contribution to policy analysis.

[9] Although there are significant funding availability issues as well.
[10] One or more iterations at a task or decision caused, for example, by inadequate information and/or poor capabilities to execute a task effectively.

3.
Structures and Strategies for Research Commercialisation in Australian Universities

Introduction

Improving the level and effectiveness of commercialisation of research performed in the public sector has been a matter of concern and analysis in Australia over at least the past twenty years.[11]

This preoccupation can be readily understood given the comparatively high levels of public investment in and performance of R&D in Australia compared with other countries. A second component was the widely held view, backed up by numerous anecdotes, that Australia performed excellent research, but was poor in translating it into wealth generation for the nation. Too many 'inventions' escaped overseas.

Most recently, the Australian Research Council (ARC) has published a commissioned report entitled 'University Research: Technology Transfer and Commercialisation Practices' (Cripps et al, 1999), which provides a detailed picture of current practice and achievement. It notes a lack of entrepreneurship, and emphasises that the processes are more an outcome of people than of procedures or university practices.

This report is not designed to simply add to this extensive literature. Rather, it focuses on the specific issues of barriers to involvement of university researchers in business enterprises, particularly start-ups, and best practice models appropriate to the higher education sector as a whole.

Development of Current Policies for Research Commercialisation

The universities have responded to these concerns and their changing role. Thus, linkages with industry and business have become the norm rather than the exception, and much higher levels of collaborative and contracted research are performed now than a decade ago.

During the 1980's, there was an efflorescence of university 'business arms', designed to encourage and exploit the intellectual property (IP) of the university. Their performance was decidedly mixed, and the notion that universities were a goldmine of IP just waiting to be tapped declined in influence. Moreover, in some cases these intermediary bodies acted as a barrier to university researchers gaining more direct experience of the challenges of commercialisation. In others, researchers

[11] See for example Twomey, 1993; NBEET, 1995, BHERT, 1996; OECD, 1997; FASTS, 1998; Matthews and Johnston, 1998.

inexperienced at research commercialisation over-valued their discoveries and blamed the business arm for its inability to realise their unrealistic expectations. This led to disillusionment of some researchers with research commercialisation.

Nevertheless, considerable learning resulted, and there developed a greater awareness and interest in the commercialisation of research among at least a growing minority of university researchers. A number of evident successes, such as Cochlear Ltd and ResMed Inc (though 30 and 20 years in gestation, respectively), provided models of the considerable returns that could be achieved in the long-term through commercialisation of health research developments.

Under the changed conditions of the late 1990s, with the considerable promise of the knowledge economy, the rewards to be obtained from knowledge-intensive products and services, and the easier availability of capital to support new ventures, there is a renewed interest in the potential return to universities, and the nation, through new business formation.

However, written policies and regulations of Australian universities for IP commercialisation, with very few exceptions, provide little encouragement for researchers to develop their own research for commercialisation and largely emphasise appropriate arrangements for others to exploit their research output.

Thus, Monash University's Research Policy states:

> Although they are important downstream outcomes of research, development and the production and marketing of goods and services is not, in general, something for which universities are well suited or adequately resourced… The university looks, rather to commerce and industry to commercialise its intellectual property.

Almost all Australian universities have in place well developed IP policies and practices that are substantially similar, apparently based on an Australian Vice-Chancellor's Committee (AVCC) Discussion Paper published in 1995. (AVCC, 1995). However they vary considerably in matters of detail.

The major common features of IP policy are:

- Definition (including copyright, patents, plant varieties, trademarks, registered designs, circuit layouts, trade secrets, and other rights resulting from intellectual activity).

- Claim of ownership of all IP produced by staff, excepting publications and other special categories.

- Student ownership of any IP produced (though some universities claim ownership of student IP also), but with strong inducements for students to vest their IP in the university, with returns similar to that of staff.

- Obligations on 'originators' to report potential IP as soon as identified, and to follow appropriate non-disclosure requirements.

- Distribution of revenue resulting from IP exploitation, after costs are covered, on a formula basis (which is highly variable[12]) which acknowledges the appropriateness of a significant, but in most cases, minority, return to the individual originator(s).

- A Code of Conduct to govern matters such as conflict of interest and confidentiality agreements.

- Requirement that staff obtain approval of Vice-Chancellor or delegated authority to take up a Directorship of an incorporated body.

Only the most general guidelines are provided about a start-up company route to commercialisation. For example, in one of the most detailed provisions, when

> commercialisation of research outcomes may be best achieved by the establishment of a company or joint venture with parties outside the University, the merits and commercial viability of an external entity must be evaluated and approvals sought in accordance with University procedures. (BLO, 1999)

The level of expertise available within Universities to make this judgement is highly variable.

With regard to the right or ability to hold equity, there is little direct guidance also, beyond a standard requirement for approval by the Vice-Chancellor before accepting any Directorship. This directive is designed to address the general issue of invitations to join an established Board, rather than the special case of a researcher taking equity in a start-up company based on the products of their own research.

However, an examination of the practices followed in establishing a limited number of new ventures based on university research suggests that, in practice, there is no prohibition on the inventor being accorded equity in a proportion corresponding to royalty revenue distributions, with regard to the university's share of the equity. This equity is commonly diluted very quickly as a result of new equity provisions for major investors.

There are no special provisions for encouraging or allowing the movement of researchers into industry, either as part of new or existing companies. Within general provisions, researchers are permitted to take a limited amount of outside work (usually up to 20% of their time), to work on contracts with industry, to supervise students working in a company, and to take secondment for some agreed period to work in industry.

[12] Formulae vary from a simple 3-way equal split between inventor, Department and University, to more complex schemes, which include a return to the University commercial company, and a sliding scale to allow a higher return to the inventor when the revenue to be distributed is small.

Management of Research Commercialisation Procedures and Practices

In the main, universities have established an executive committee to oversee IP and other research commercialisation issues. The operations are managed through an 'arms length' organisation with direct responsibility to manage the university's commercial activities, including research contracts and consultancies, registering and exploiting IP, establishment of spin-off companies, and sales of products and other services.

The great majority of these organisations are incorporated, though with a few notable exceptions, such as the Business Liaison Office at the University of Sydney. While comprehensive data are not available[13], the evidence is that about two-thirds of these organisations operate with a monopoly, or first right-of-refusal, within their universities. The remainder have in principle to compete for the research commercialisation business in the university, but in practice being located on campus provides such an advantage that they are still the first port-of-call.

While these companies play a considerable role in facilitating commercialisation of research and in providing the important legal and contractual support services, a substantial responsibility remains with the researcher themselves. Based on the procedures at the University of Sydney (Appendix C) a typical process might have the following stages and responsibilities:

Table 3: Typical research commercialisation stages

Stage	Responsibility
Research	Researcher
Report of possible IP	Researcher
Supply of Record of Invention Form	BLO
Completion of Record of Invention Form	Researcher
Scientific Literature Search	Researcher
Patent Database Search	Researcher
Review of Commercial Potential	BLO
Evaluation of Patentability	Patent Attorney
Provisional Patent	BLO
Search for Licensee	BLO, with assistance of Researcher

The common model is to provide protection for IP only through the relatively inexpensive provisional patent phase, and to use the twelve months of protection to establish a licence with an external party with an appropriate royalty return. If an industry partner cannot be found within the twelve months, the application is usually allowed to lapse, and the ownership of the IP reverts to the inventor.

[13] Based on a 1999 survey conducted by the Australasian Tertiary Institutions Commercial Companies Association (ATICCA) of their membership to which they had 20 responses.

However while regulations are largely common, practice varies considerably. This can largely be attributed to different levels of expertise, customer orientation, and empathy with researchers on the part of staff of the commercial arms. In addition, there is great variation in the extent to which the executive of universities provide 'space' and active encouragement for entrepreneurialism, and the cultures of universities, Faculties and Departments support research commercialisation. Finally of course, the resources to support research commercialisation vary considerably between universities.

These differences are all important. However they are open to only the most general kinds of influence beyond the individual university.

Performance of Universities in Commercialising Research

It is very difficult to provide anything like an adequate scorecard of Australian university performance in research commercialisation. Universities, for various reasons, do not make these data readily available. Indeed, until recently, many did not collect such data and there was no pressure to report it.

Surveys have generally been limited by poor response rates, frequently justified on grounds of commercial secrecy - a claim that would bear only limited examination. However, the sense, and reality, of competition between universities, and university commercial companies, has probably provided the biggest obstacle to establishing better measures of performance.

On the basis of a very limited response, ATICCA identified a total ofA$31 million revenue generated by research commercialisation, out of a total income of $240 million in 1998. On this basis, research commercialisation generated only 13% of income, and hence might be regarded as not of particular importance. However, it did consume on average 29% of time.

With regard to performance, the following figures were identified.:

New inventions disclosed	274
New patent applications filed	161
New patents issued	103
New licences and option agreements	63
Current licences and option agreements	231

It is difficult to make an assessment of these data, given the limited response and lack of any clear benchmarks for comparison. What might be indicated by the figures for current and new licences and option agreements is an increase in the rate of new licensing.

With regard to start-up companies, 46 were reported for 1996-98. Again, it is difficult to provide an objective basis for assessment. Against US levels of spin-offs, this is a low figure – MIT alone, for example, spins off around 150 companies annually; but the environment for commercialisation is very different. Perhaps the only valid conclusion that can be drawn is that the rate of formation of these companies, and their visibility is increasing.

It should be noted that medical and health-related research figures prominently in all reports. In the ATICCA survey they are responsible for 42% of activity.

A detailed evaluation of the performance of research commercialisation from the perspective of the researcher will be provided in the next Chapter. In this Chapter, we will present the perspectives developed from more than 40 interviews with senior and experienced people (Appendix G) involved with various aspects of the commercialisation of research from Australian universities.

Howells and McKinlay (1999) have identified six components, or stages, of good practice procedures for IP management, in their review of the commercialisation of research in Europe. These components have been modified to provide a set of criteria against which the performance of Australian universities in research commercialisation, as reflected in the literature and interviews, will be assessed.

1. *Effective monitoring of research activity to identify potential IP*

As indicated above, almost all universities place responsibility on the researcher for identifying and reporting potential commercialisable research. However, it is apparent from interviews that many researchers are not confident that they have the necessary knowledge to identify potential IP. "*I think I know it's not a goer with the big pharma companies. But I just don't know about the smaller ones, or whether this might have veterinary or agricultural applications".* Still others, with perhaps less experience, don't even think of possible commercial applications.

Many commercial arms operate in essentially a passive mode, awaiting the researchers with their commercialisable ideas to come through the door (and complaining when they don't). Some provide courses to provide generic skills in identifying commercial opportunities. These may be valuable, but they suffer in attracting only those already interested, and generic skills are often insufficient in addressing a particular case.

Some carry out a trawl through Departments from time to time, which is likely to be far more effective than the passive approach. But the establishment of effective long-term relationships between researchers and commercialisation staff seems to underpin most successful cases.

Howells notes, in the case of Europe that:

> Most universities acknowledge that they are poor at scanning and screening. Disclosure of research output has therefore been poor. Mechanisms to evaluate potential of research for exploitation and commercialisation, and how research should be handled if it merits commercialisation, have also been partial and in most cases ad hoc, unlike the commonly used technology evaluation protocols and manuals that appear to be employed in many Canadian and US universities.

The same arguments apply, with even greater force, in Australia.

2. *Commercialisation readiness*

There is considerable evidence that most universities do not employ procedures and protocols that provide the necessary information base for substantiating IP claims, and facilitating due diligence searches. County Investment Management recently withdrew from the development of a proposed Medical Research Investment Fund on the grounds that it was impractical. They particularly urged the need for:

> a commonly accredited mechanism for management of IP that would make early stage investment feasible. Such a mechanism might involve a credit rating system for research institutions which took into account their IP management procedures such as maintenance of laboratory record books, and procedures for identification and protection of commercialisable IP.[14]

3. *Identification of winners*

Establishing a comparative track record for success in picking winners in technology ventures by venture capitalists is possible. However, with a much smaller portfolio, generated by the various activities of their university, such an exercise for research commercialisation is notoriously difficult. However there is evidence of a relatively clear and shared 'pecking order' of performance by university commercial arms, which suggests, at least in some informal way, such judgments can be made.

What emerges clearly is that this performance is correlated very strongly with the capabilities of the chief executive, particularly their industrial and commercialisation experience. The most important means of improving the 'hit rate' is selective recruitment of people with these skills, and in the longer term, development of a recognised career pathway in research commercialisation. This experience accords with the understanding of the world Science Park movement, where it is held that the major factor underlying the success of a Science Park is the quality of its CEO.

4. *Negotiation of appropriate commercialisation and protection regimes*

Considerable experience appears to have been developed in this area, though as it is a competitive field, the leading edge is continually advancing. There is a corpus of experienced IP evaluators and negotiators, though not sufficient to allow every university to have one.

The move among some universities to remove the monopoly for their commercial arm (see next Section) may provide the opportunity for a degree of concentration of the market for commercialisation of research in the hands of those with the necessary capability, rather than the quasi-regulated model of one company per university.

One of the very significant challenges is that of balancing the needs and interest of the researcher/research team, with those of the university, and even the nation. With most researchers operating under extreme pressure on resources, and the need to invest considerable time in raising what is required to continue their research, there is an inevitable demand for short-term funds. Thus the researcher is more interested in the

[14] Quoted in Australian R&D Review, June 2000, p.16

near-term cash flow arising from licensing, or even sale, compared with the potential of much larger but highly uncertain returns over a longer period.

5. *Management of the commercial portfolio*

There is adequate evidence that the universities, to varying extents, have developed the capability to manage a portfolio of licences. However there are much less accumulated skills in managing the stages of development of start-up firms. Such firms go through a number of critical thresholds in their development, in management, marketing and technology, each of which can prove terminal. In particular, given the uncertainty and risk, there is a tendency for hierarchical universities to rely on the familiar command-control management mechanisms, and appoint a senior executive to guard the university's interests.

In contrast, what is most needed is directors whose interest is in the company succeeding. One such category is those with the necessary knowledge of the technology. In general, the university should see its return coming through the deal it negotiates, and the extent of its equity, rather than in engaging in hands-on management of start-up enterprises.

Howells and McKinlay have also identified good practice procedures for managing the formation of spinout companies. These are:

> Providing clear and transparent guidelines to all university staff who may be wishing to set up a spin-off company, so that the prospective entrepreneurs have a solid framework *before* they make their judgement about whether to proceed with setting up the company and how this should be done.
>
> The university, once contacted, should also proactively provide information, contacts (for example with venture capitalists) and support on how to *establish* a company.
>
> If the university owns the IP which protects the innovation or technology which forms the basis for the company, it needs to *jointly* discuss and decide at the outset with the academic inventors/prospective entrepreneurs whether setting up a company is the best option.
>
> Prospective entrepreneurs should be allowed to remain on a part time research or teaching position with the university if they so desire; there should be a clear *demarcation* of responsibilities and practices between the two jobs.
>
> Provision of advice to prospective academic entrepreneurs on what is required to effectively *operate* and run the company and what additional manpower expertise may be needed to be recruited to fill in gaps (often here a financial director).
>
> Associated with this, help potential founders set up *business plans* to define clear commercial goals for the new company as well as addressing market research and sales strategies.
>
> To quickly decide whether the university will provide all or some *seed* capital or venture funding for the new company and to facilitate contacts with other venture capital organisations.

> Prospective entrepreneurs who want to leave the university employ should be offered a transition employment period, starting with continuation of the payment of a full university salary and gradually shifting to self-employment as the company takes-off and with an option to return to an academic at a later stage.

It is apparent on many of these measures, that the majority of Australian universities have some distance to travel before they can approach this level of good practice. In particular, issues concerned with mobility of staff from the university into start-up companies appear to have received almost no consideration in policy terms.

New Developments in Commercialisation of University Research

There are a number of policies and practices which have begun to emerge over the past year or two and which signal a significant shift in some quarters about the perceived potential of commercialisation of university research under the new conditions of the global knowledge economy, and the emergence of global markets for research. (Appendix C)

These include:

- **A greater emphasis on commercialisation through start-up or spin-off companies**.

  The well-established evidence of the successful commercialisation of research through spin-off companies in the major US universities, and a growing view in Europe that generating new enterprises to exploit research developments can be more effective than licensing IP to existing companies, appears to be having an influence in Australia.

The advantages of such an approach to the nation are seen as:

- job creation (direct and indirect);
- increased likelihood of downstream operations in Australia;
- spawning of flow-on spin-offs, leading to a start-up agglomeration;
- opportunity for gaining greater value multipliers through exit strategies such as public offerings and trade sales.[15]

However, there is doubt whether arguments of national advantage were the prime drivers of this emerging shift in practice. Rather, it was likely to be the dramatically growing value of technology-based companies, the surge in the value of the US NASDAQ share list, and the greatly increased availability of venture and other forms of capital to invest in research-originated technologies and companies.

[15] Adapted from Cripps et al, 1999, p.155.

As yet, only a few universities have moved towards committing themselves to start-up company formation as a significant component of their research commercialisation strategies. None have established publicly available protocols to guide the process. Indeed it is a period of considerable experimentation and cautious learning. However, as our selected case studies show (Appendix C), there is a considerable burst of new spin-offs.

- **Decentralised mechanisms for research commercialisation**

The case studies of both the Universities of Melbourne and Queensland reveal a move to decentralisation of the scanning and screening component of the research commercialisation process. Staff of the commercial arm are being located within the Faculties with the explicit aim of improving the capture of research outputs with commercial potential ie to expand the number of candidates for the potential portfolio.

At Melbourne this shift is accompanied by a transfer of ownership, and responsibility, to the researcher. At Queensland, ownership is still vested in the university.

At the same time, the stages of negotiation and management are being maintained within the central organisation, in order to ensure access to the necessary skills and judgment involved in commercial negotiation.

- **Transfer of ownership from the institution to the inventor**

The new regulations at the University of Melbourne include a transfer of ownership of IP from the university to the inventor/researcher. There is no longer a requirement to inform the university. Rather they are free to make their own commercialisation judgments, to invest in the necessary protection, and to reap substantial rewards. In this they can choose to go it alone, be assisted by the University's commercial arm (MEI), or to seek alternative commercialisation advice and assistance.

This shift constitutes a first in Australia, but is closer to the arrangements in some leading US universities (eg MIT) and UK universities (Cambridge, UMIST). The very considerable success of what is commonly referred to as the 'Cambridge phenomenon' is attributed to the quality of the researchers, and the relative autonomy under which they operate within the 'college system'. As a consequence, the growth of a concentration of technology-based firms has been more a case of spin-out (companies with which the university has no ownership, legal ties, and occasionally, knowledge) than spin-off (companies in which the university has a continuing involvement or interest).

- **Abolition of monopoly in commercial arm operations**

  An increasing number of universities are exposing their commercial arm, at least in principle to competition from other university commercial arms, and from the directly commercial investment industry. The extent of the real competition, or the time taken to establish genuine market conditions, is as yet unclear.

- **Direct provision of capital**

A number of universities (eg. ANU, Curtin) have decided, or are in the process of deciding, to adapt their investment strategies to permit a certain level of investment (of non-Commonwealth funds) in equity in university-originated start-up companies, or to enter joint venture capital raising with investment firms.

4.
Survey Findings

Introduction

There have been a number of policy reports on research commercialisation and related issues over the last decade. The evidence collated in these reports tends to rely heavily upon highly informed, but essentially anecdotal, opinions communicated via interviews. In contrast, there has been relatively little wider-sample statistical data collected on perceptions of research commercialisation problems - particularly data that reflects the opinions and experiences of researchers in the laboratory and business people with direct experience of commercialising university research outcomes. Where survey work has been carried out, often as part of DETYA Evaluation and Investigations program studies, the results have provided useful evidence for calibrating interview-based findings.

It was therefore decided that an attempt should be made in this study to collect wider sample statistical data via a web-based structured submission process. Appendix D contains a detailed discussion of the findings obtained from the on-line submission process. This chapter summarises the main results and discusses their implications for the study.

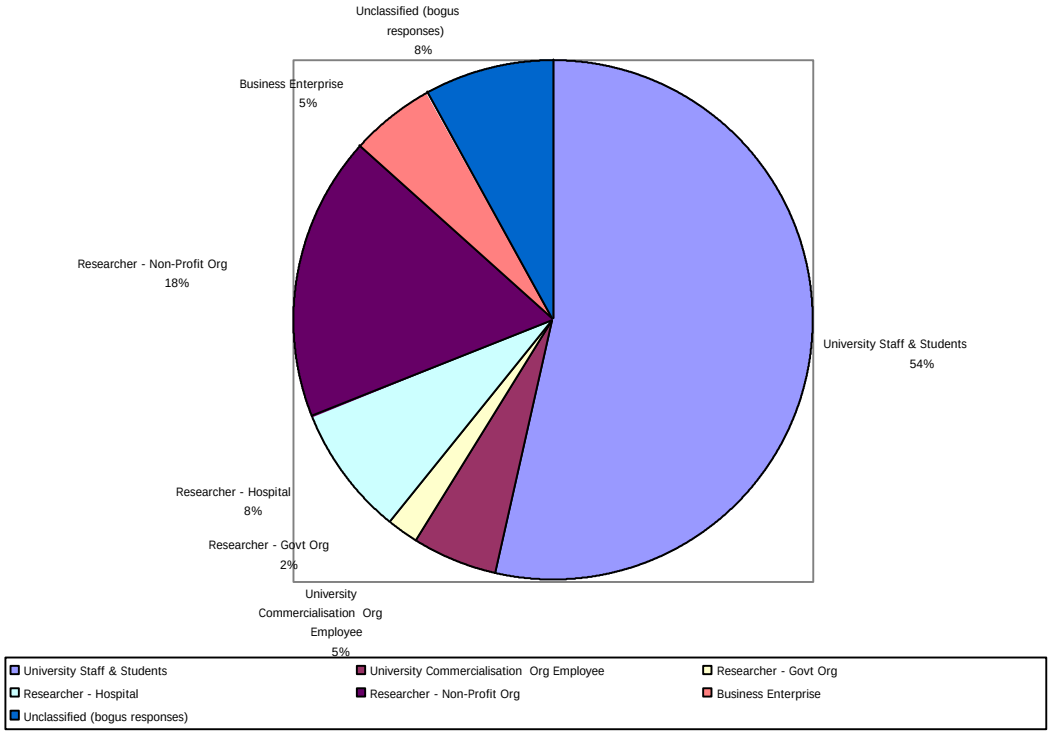
The form (see Appendix H) has been designed to allow both university staff to respond *and* people in other sectors who may wish to submit their views on the problems faced within universities. The rationale for this is that commercialising university research often involves research collaborators or commercial partners in organisations in other sectors, notable the CSIRO, CRCs, private-non profit research organisations and of course business enterprises.

On-line Responses

As of 12 July 103 useable responses (out of 113 in total) have been received via the on-line form and 14 longer textual submissions from researchers who have completed the form. The results discussed below are based upon the 103 useable responses available for analysis.

The following pie chart shows the breakdown of these responses by the sector of the respondent.

Figure 2: Sectoral Breakdown of Responses



Just over half the responses are from university staff & students (primarily staff with a few graduate students). There have been six from staff in university research commercialisation arms. Responses from people outside of the higher education sector are dominated by researchers in the private non-profit sector and from researchers in hospitals.

The data-set has been be analysed with respect to sectoral location as two groups of respondents:

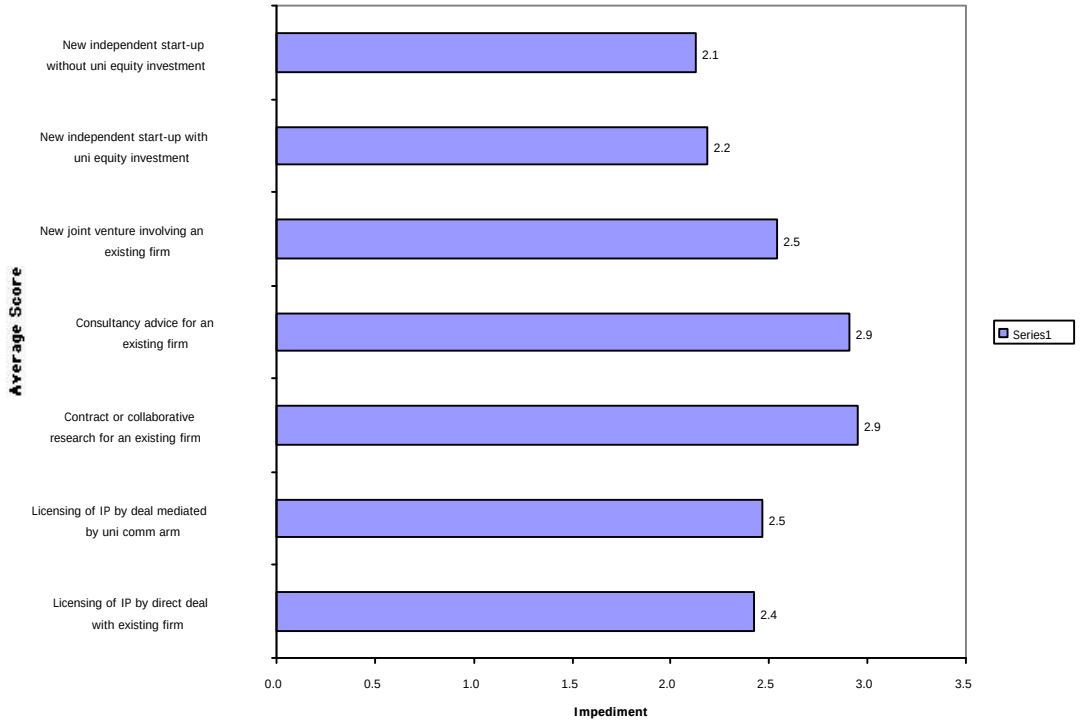
- university staff & students, and
- staff from university research commercialisation arms and all other respondents.

This division of the sample allows the characteristics of the responses from each sector to be compared in order to identify differences between the two sub-samples.

Preferred Research Commercialisation Avenues in Australia

The following graph shows how the total sample of respondents have collectively rated each of the research commercialisation avenues specified *with current research commercialisation impediments in place*. A score of zero to five was used, with the additional option of providing a 'no view' response. These averages exclude 'no view' responses.

Figure 3: Preferred Research Commercialisation Avenues



These results indicate that the most preferred commercialisation avenues are contract or collaborative research with an existing firm and consultancy work for an existing firm.

These can be very effective mechanisms for technology transfer/collaboration when there are adequate industry '*receptors'* for the technology. These avenues are usually associated with incremental innovation as distinct from more radical scientific and technological advances - and the former advances are more frequently made than the latter.

It would be unwise to read any more into these results, save for noting that the least preferred avenues are new business start-ups, and that the general pattern of these results, suggests that the avenues with the best risk to effort ratio are preferred. Technology transfer via research & consulting linkages is relatively risk-free and does not attract the 'overhead time' effort and stress that licensing arrangements tend to require.

The Impact of Impediments on Preferred Research Commercialisation Avenues

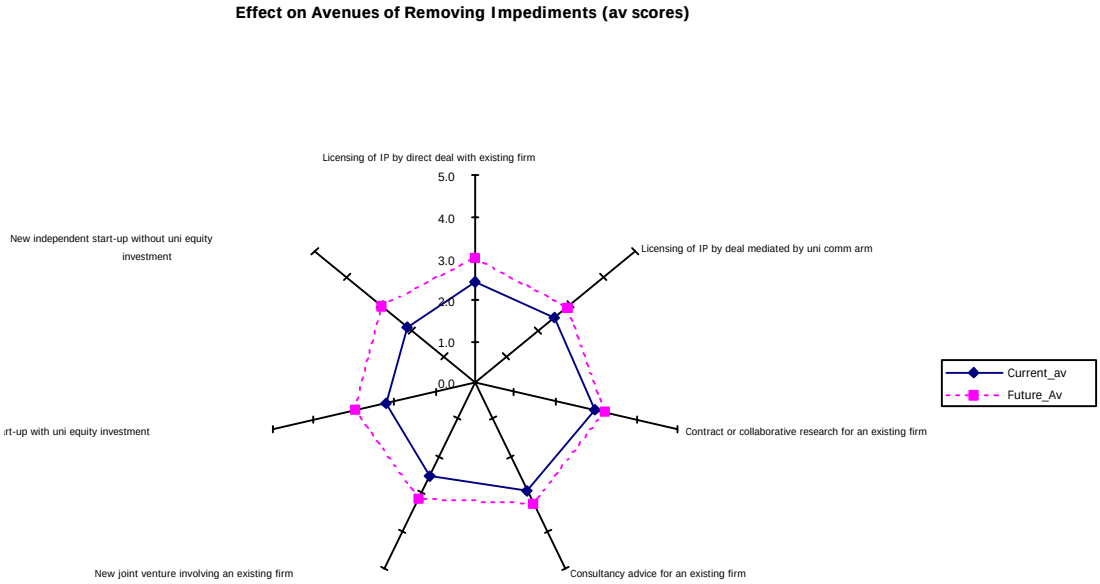
This question is pertinent to policy formulation because there is a view that a *broad spectrum* of university-industry interactions is more effective than a limited spectrum in closing the cultural gap between the two sectors - thereby facilitating the commercialisation process.

A broad spectrum of interactions tends to involve beneficial 'interactive' and knock-on effects between the different channels that raise the overall effectiveness of the process.[16]

Respondents were also asked to provide another set of ratings of the appropriateness of these commercialisation *avenues assuming that current impediments have been removed*. This question was designed to allow us to test whether or not current impediments affect preferred commercialisation avenues.

Figure 4 illustrates the impact of impediments on preferred commercialisation avenues by plotting both sets of scores on the 'spokes' defined by each commercialisation avenue. The unbroken line describes the current situation, the broken line the hypothetical impediment-free situation.

Figure 4: Effect on Preferred Research Commercialisation Avenues of Removing Current Impediments



These results suggest that current impediments *are* perceived to affect preferred research commercialisation avenues, and (assuming that preferences relate to actual activities) current impediments may have the effect of:

- limiting new firm start-up activity that involves university equity;

[16] For example, doing consultancy work for a firm improves mutual understanding of each partners' research strategies, capabilities and modes of operation etc. This can facilitate subsequent research and commercial partnership building. Because these university-industry interactions involve learning-by-doing that 'de-bugs' these linkages and increases the probability of successful future linkages many governments now actively subsidise such linkage-building in order to generate a self-sustaining non-subsidised learning-by-doing process - effectively as 'launch aid'. (Matthews and Johnston, 2000)

- limiting new firm start-up activity that *does not* involve universities making an equity investment;
- limiting activity that involves licensing IP via a direct deal with an existing firm;
- limiting joint ventures with existing firms.

The differences for contract and collaborative research, consulting and licensing deals mediated by university commercialisation arms are less marked.

In general, current research commercialisation impediments appear to restrict the 'breadth' of commercialisation activity - producing a 'less rounded' commercialisation profile.

Impediments to Research Commercialisation in Australia

Finally, we considered the relative strength of a number of key impediments to research commercialisation. The impediments covered are:

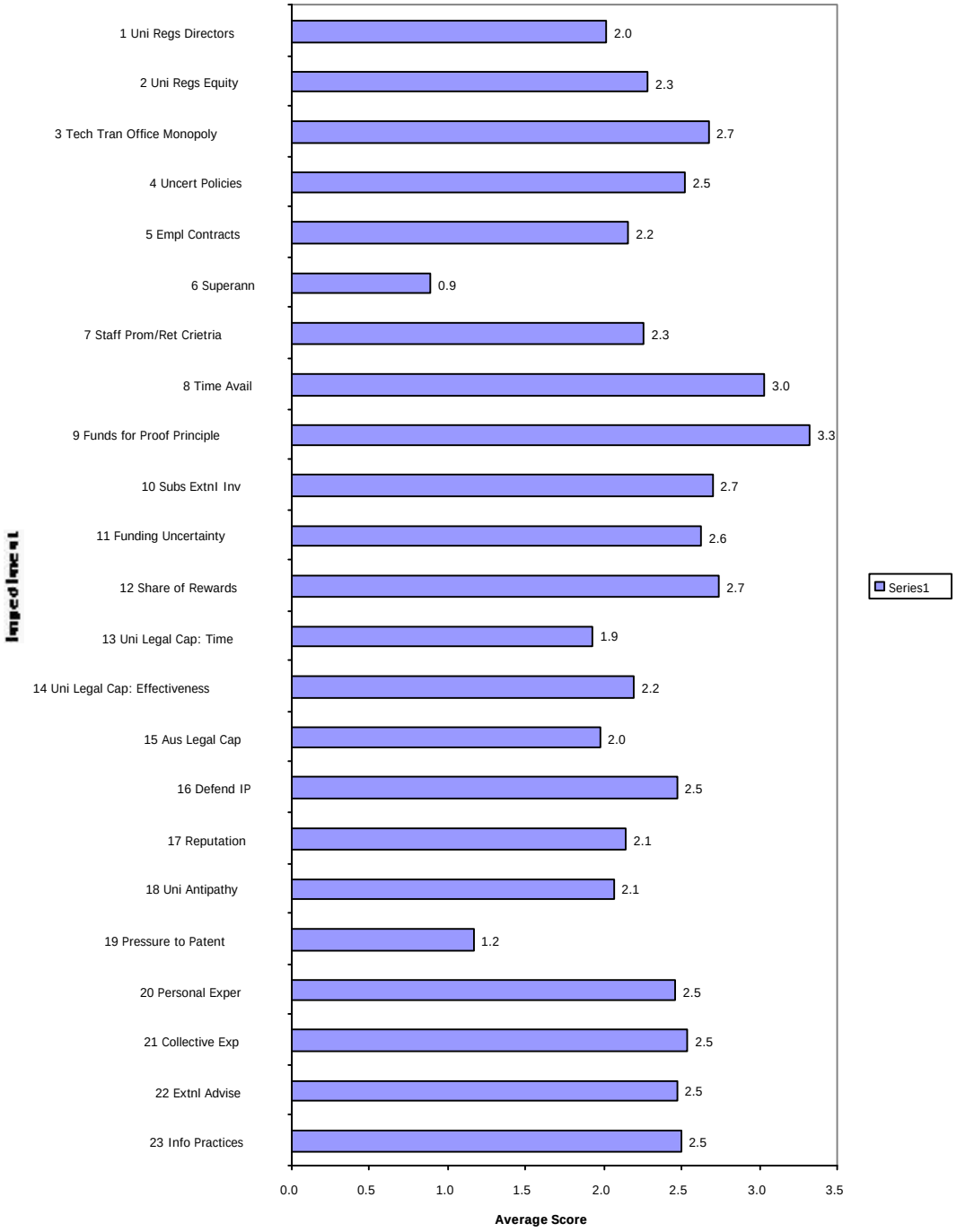
Table 4: List of Impediments Considered

Administrative
1 University regulations - constraints to taking up directorships
2 University regulations - constraints to holding equity
3 Limits to commercialisation activity caused by the University technology transfer office's monopoly over intellectual property deals
4 Uncertainty and confusion over University policies and whether or not they actually have to be followed.
5 University employment contracts
6 Superannuation practices
7 University promotion & staff retention criteria
8 Time available for research commercialisation given research, teaching and administrative burdens
Financial
9 General availability of funding for post-research activities such as 'proof of principle' and securing IP that are pre-requisites for significant commercial investment
10 Access to external investment funding for subsequent commercialisation activities (e.g. by Venture Capitalists)
11 Uncertainty about future government Research and Development funding availability
12 Insufficient share of financial rewards when the IP is owned by the University
Legal infrastructure
13 Lack of legal capability in the University to secure intellectual property within required lead times
14 Lack of legal capability in the University to secure intellectual property effectively
15 Insufficient general capability in Australia to rapidly secure defensible IP
16 Insufficient general capability to defend IP in order to obtain economic advantage
Cultural
17 Perceptions by research colleagues that commercial activities compromise academic reputation
18 General antipathy in Universities towards commercial activities stemming from research
19 Pressure from the University to secure intellectual property via patenting irrespective of the nature of the technology or the stage at which its development is at
Experiential
20 Insufficient previous personal experience of research commercialisation given the level of tacit knowledge required

21	Insufficient collective experience of commercialisation within the University given the level of tacit knowledge required
22	Insufficient access to external advisers with practical experience of commercialisation
23	Insufficient information available on basic commercialisation practices and procedures to offset a lack of personal experience

Figure 5 indicates how these impediments were rated. The same 0 to 5 scoring system has been used as above, except that respondents were given the option of also selecting 'not applicable' in addition to 'no view'. In this context, respondents were asked to rate impediments in terms of relative severity in the impact upon levels of commercialisation activity. The average scores exclude the 'no view' and 'not applicable' responses.

Figure 5: Rating of Different Impediments to Research Commercialisation Activity



On this basis of this sample the most severe impediment to research commercialisation is funding for 'proof of principle', with the time available for research commercialisation and the share of rewards that can be obtained and a university technology transfer arm monopoly over IP deals also featuring strongly.

Most of the impediments covered scored around 2-5 (moderate impediments), with the exceptions of superannuation policies and pressure to patent from the university.

We obtained further information from the respondents on why they had given relatively high scores to the university regulation-based impediments. It turns out that these impediments were given significant scores as much because there is general dissatisfaction with the 'business process' efficiency with which universities handle a wide range of commercialisation matters rather than constraints caused by rules and regulations.

Appendix D contains a more detailed discussion of the results that compares the responses of university staff with other staff. In general the views expressed are very similar, and are mainly influenced by university staffs' greater familiarity with the issues covered.[17]

Conclusion

Researchers and other informed people, take a wide and considered view of the relative applicability of the various research commercialisation avenues that are available. In particular, they recognise that collaborative/contract research and consultancy work can be major channels for commercialisation.

This probably reflects the fact that many research results are too incremental to warrant commercialisation via a start-up company. This in an important point because is places Australia at something of a disadvantage vis-a-vis countries with more advanced innovation capabilities in the private sector because there is less scope for such university-industry interactions in Australia.

The major impediments to research commercialisation are the availability of funding for proof-of-principle activities and the subsequent investments necessary to produce cost-risk-return probabilities that will attract external investors. This funding problem is exacerbated by factors such as insufficient time available for dealing with research commercialisation given other duties and responsibilities.

Perhaps most importantly, the findings from both the on-line submission form and (far more strongly) from personal communications and the textual submissions received point very strongly towards a single generic problem that affects all the universities covered. This is the low level of business process efficiency exhibited by many universities and their research commercialisation arms in handling these procedures and decisions.

This finding compliments that of the various detailed case studies in that it highlights the impact of learning-by-doing in handling research commercialisation matters. This aspect of business process efficiency is driven partly by the lack of cumulative experience gained from previous research commercialisation activities and partly by the tensions caused by the need for university administrators to operate in a new, more business-like environment than has been the case in the past.

[17] This is reflected in higher overall scores for most of the impediments covered.

These consultations have not revealed that there are 'internal' university policies and procedures that constitute direct barriers to research commercialisation. Instead, they have revealed that current impediments are, to a significant extent, driven simply by the need for more experience in research commercialisation on the part of both researchers and research commercialisers - a process that will tend to improve business process efficiency within universities and their commercialisation arms.

If these current impediments were to be removed then a more rounded profile of research commercialisation activity would result- with more activity in all commercialisation avenues. This is likely to lead to beneficial knock-on effects that would play an important role in improving university-industry interactions in Australia.

5.
Overseas Experience

Before discussing the arrangements, and their policy significance, it is necessary to consider the strengths and weaknesses of attempts to identify best practices in the arrangements for handling research commercialisation.

Identifying Best Practices when National Circumstances Differ: a Co-evolution Perspective

Effectiveness in commercialising university research is determined by a number of factors that characteristically interact in complex ways - particularly in a country-specific manner.

Many of these factors relate closely to national-cultural circumstances that influence both the substantive and the perceived role of universities in the national economy. Many factors relate to the even more general cultural attitudes towards behavioural norms and socially acceptable behaviour. For example, attitudes towards seeking and demonstrating personal wealth in the US are very different from those in Australia. Philanthropic donations to universities, encouraged by the tax system, are partly a means of *demonstrating wealth* in the US - something that the 'tall poppy' syndrome in Australia militates against.

'Best practice' in arrangements for research commercialisation cannot ignore these factors. Consequently it is logical to treat best practice as a *match* between national circumstances and university motives, policies and procedures in the sense that the two sets of factors *co-evolve* over time. Co-evolution is an interactive process in which developmental trajectories impact upon each other *via learning-by-doing*.

For example, many US universities, such as Stanford and MIT, have learnt from experience that a relatively relaxed attitude which favours (non-revenue generating) technology transfer over (revenue generating) research commercialisation leads to indirect revenue gains in the longer term from donations from researchers who have become wealthy. These circumstances evolve, and are rarely the outcome of specific strategies and plans. Indeed, revenue generation from research commercialisation is, for the elite US universities, a welcome but not a targeted outcome.

In effect, to use the basic approach recommended in the Wills Review, creating a *virtuous cycle* of academic-industry-government interaction, is a crucial policy objective. However, there is more than one type of virtuous cycle that can be created and the appropriate type of virtuous cycle is largely determined by national circumstances.

It follows that best practice should be treated as the extent to which university policies and procedures *match* national circumstances at a given time (static effectiveness) *and* help to create a co-evolution dynamic that will improve the situation in the future (dynamic effectiveness). Recognising the dynamic effectiveness dimension is particularly important because optimising static effectiveness may, in some situations, harm dynamic effectiveness.

Variations in the scope for *learning-by-doing* play a major role in this co-evolution dynamic (ie dynamic effectiveness). For example, there is both more to learn about forming successful spin-off start-up firms than completing simple IP licensing deals *and* the potential financial rewards to commercialisation via start-ups (and also the risks) are greater than they are for commercialisation via licensing.

A university that strongly prioritises commercialisation via licensing can lock itself out of, what might turn out to be, a more rewarding commercialisation trajectory based upon start-up firms. In such a situation the prioritisation of commercialisation via licensing may well be the optimal solution in terms of static effectiveness.

However it entails limiting the university's potential to exploit the *dynamic effectiveness* driven by creating a pool of knowledge about new business start-ups that, in turn, increases the probability that future start-ups will be successful. In this way, university policies and procedures have the effect of 'closing off' future options. Policies that are based upon optimising static effectiveness will, by definition, tend to reinforce national or regional circumstances that are one cause of the problem.

This policy trade-off between targeting static and dynamic effectiveness is recognised in the economic literature on technological innovation.

Findings

We have assessed the arrangements for handling technology transfer and research commercialisation at four leading overseas universities. These are:

- MIT;
- Stanford;
- Oxford;
- UCLA.

Appendix E contains profiles of each university's arrangements. The key features of these arrangements are summarised in Table ? in this Appendix .

Our objective in this discussion is to highlight the salient aspects of these policies and procedures by drawing upon the co-evolutionary perspective outlined in the previous section.
These, and other universities considered in less detail, exhibit notable variations in how IP is handled and in the division of income from commercialisation. However, the norm is for the university to claim much of the IP created by staff (though with copyright on written work excluded) with the exception of MIT - which only claims IP arising from targeted and sponsored research.

In the US the potentially problematic issue of the pricing of research contracts is eased because the Federal Government sets overhead rates for federally sponsored research for each university. These rates tend to be simply applied to research funded from other sources.[18]

From a co-evolutionary perspective, US universities have developed policies and procedures for handling research commercialisation that reflect a long history of close industry-academic associations, relative freedom to move between academia and industry over a professional career, and a strong public interest motive that prioritises technology transfer over research commercialisation.

Conclusion

The approach in US universities is an outcome of a long history of co-evolution in which universities and industry have interacted and learned, via trial and error, to work to mutual advantage across a broad spectrum of commercialisation activities. This process has been taking place since the early years of the twentieth century (and in some cases prior to that).

The emphasis on start-up firms in the US, unlike in Australia, is the consequence of recognising the special circumstances under which start-ups are the best means of research commercialisation. This is demonstrated by the better balance between start-up activity and other forms of research commercialisation.

In Australia, the emphasis on start-up firms tends to reflect a more complex situation in which the narrower spectrum of research commercialisation activity, particularly in the form of interactions between existing firms and researchers, is partly driven by low industrial R&D investment levels and associated S&T capabilities. There are fewer opportunities to build links with existing firms and for staff to move between these firms and academia, hence the greater reliance on start-ups for research commercialisation.

[18] Examples of these rates are: MIT (60%); University of California (47%); Stanford (58%); Caltech (56%); Harvard (64%). CVCP, 1998.

6.
Summary and Conclusions

Major Findings

The starting point for this study was the Wills Review's finding that there may be institutional barriers to the involvement of researchers in new business enterprises, specifically in relation to holding equity, directorships and moving between academia and industry.

Although such barriers generally appear to be less of an issue in universities than for government research organisations, the dominance of universities in performing health and medical research means that the overall national impact of such barriers in the health and medical area may be greater than that of government research organisations.

Australian universities face a relatively unique challenge when attempting to facilitate research commercialisation in the medical area because their world-class science coexists with a less technically capable domestic industrial base. This is a very different situation than in the United States and in the leading European economies, which possess technically sophisticated multi-national firms able to interact more easily with university researchers.

Structural Constraints

This study has found that, in general, the policies and procedures in universities do not constitute direct barriers to researcher involvement in research commercialisation:

- while holding equity is still relatively rare, there are few if any formal prescriptions against it; however some universities are, in practice, cautious given bad experiences;
- the holding of Directorships generally requires the approval of the Vice-Chancellor, but is normally granted; however policies do not address the specific situation of start-up companies;
- there is little explicit consideration of mobility between academia and industry to support research commercialisation, though general policies do provide for such possibilities;
- the financial incentives for commercialisation activities largely rest in the prescribed royalty return to the inventor, which varies somewhat between universities; university promotion policies allow such performance to be taken into account, though the evidence is that the weighting attached is often small.

Universities are increasingly keen to generate revenue from this type of activity and are putting in place processes, and targeted funding, to facilitate research commercialisation. As a consequence performance and revenues are undoubtedly rising.

Across the university sector, regulations concerning research commercialisation are largely common. However practice varies considerably. This can largely be attributed to different levels of expertise, extent of encouragement for entrepreneurialism, and resources available to support research commercialisation.

Business Process Inefficiencies

However, even though there are few institutional constraints, evidence collected from a number of sources in this study suggests that there are serious impediments to research commercialisation arising from *business process inefficiencies*; ie the way in which research commercialisation arrangements are handled in practice.

These business process inefficiencies can introduce an expectation amongst researchers that the commercialisation process will be time-consuming, stressful, and "not worth the candle". As such, it may only damage their core research output. This fear can constitute a major barrier to research commercialisation.

These business process inefficiencies can, to a large extent, be attributed to the relatively recent growth of research commercialisation activity in Australian universities – in other words to a lack of cumulative experience in handling these complex processes. As cumulative experience increases, particularly in launching start-up companies, the business process efficiency can be expected to increase, thus adding to the virtuous cycle sought in the Wills Review recommendations.

This learning process will also assist in providing researchers with both written information and tacit knowledge on opportunities for research commercialisation and how it can be achieved effectively.

However, this study has revealed that the process of learning-by-doing may be severely impeded by shortages of funding for 'proof-of-principle' and for subsequent investments that produce commercially viable propositions. Not only may this block specific ventures; it may also limit the beneficial learning-by-doing process that will eventually improve business process efficiency. The government's recent announcement of the Biotechnology Innovation Fund specifically targeting the proof-of-principle funding problem in the bio-medical area is therefore an important step forward in enabling the virtuous cycle.

The role of learning by doing in enabling universities to participate in the virtuous cycle is outlined in the figure below. This process incorporates the positive effects of using revenue from commercialisation activities to invest in key aspects of the commercialisation process - generating additional gains in efficiency and effectiveness.

The role of learning-by-doing in enabling universities' participation in the virtuous cycle

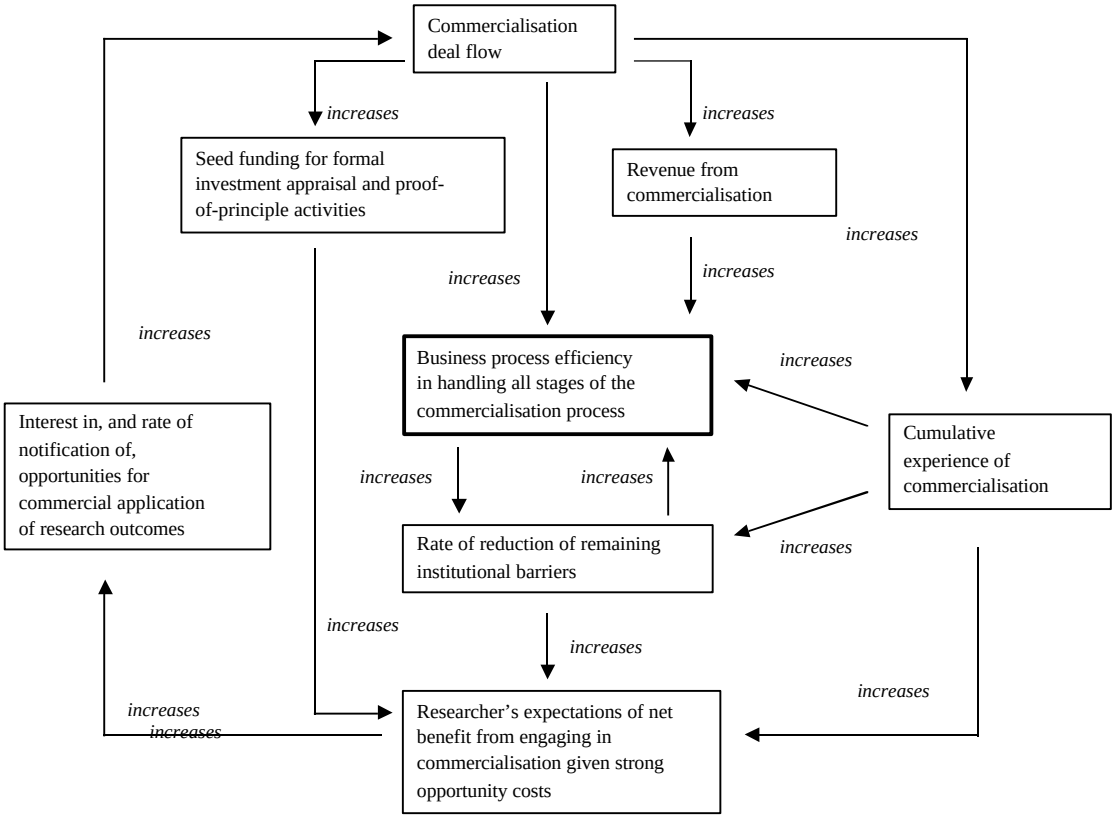


Figure 6: The learning-by-doing and re-investment process

Appropriate strategies

This study has highlighted the way in which some leading Australian research universities are now seeking to distribute their capability to scan research activities for commercially promising advances and to stimulate interest in research commercialisation throughout the institution.

Interestingly, however, in one case (the University of Melbourne) this strategy is combined with a devolution of responsibility for handling IP to academics, in another (the University of Queensland) this strategy is combined with the centralised handling of IP. In the latter case, this strategy is based upon recognising the need for experience at key 'deal closing' stages in the negotiation process. In another case (University of Sydney), traditional centralised processes appear to be working fairly effectively.

The simple conclusion is that strategy and management of research commercialisation within universities is situation-dependent and heterogeneous. 'One-size-fits all' nostrums will not work.

Best Practice

With regard to identifying *best practices* in arrangements for facilitating research commercialisation this study concludes there would, nevertheless, be advantages in developing and disseminating a generic business process framework for analysing university research commercialisation. Each organisation can develop and test its own approaches against the model.

The following Table identifies the key stages involved in research commercialisation from a business process perspective. The commercialisation process is treated as a process of scanning for options, developing these options and selecting the most promising options for commercial exploitation.[19]

This framework is offered as a potentially useful device for understanding the problems and constraints faced by universities and the strategies that they are developing to deal with these problems.

[19] This framework is loosely based upon the 'stage-gate' approach used very effectively to manage industrial innovation processes, see Cooper, 1990.

Table 5: A Generic Business Process Model of the University Research Commercialisation Process

Phase	Stage	Inputs	Activities	Outputs	Resource Requirements	Constraints
OPTION DEVELOPMENT PHASE	SCANNING & REPORTING: Identifying commercialisation opportunities arising from research and/or external business requirements.	Research findings matched to either new or existing commercial opportunities	Voluntary or compulsory notification on inventions with commercial potential. Plus, less formal communications externally.	Invention disclosure documents and/or tacit knowledge of emerging commercial opportunities	Minimal, main emphasis is on intra-university communication and communication with external organisations	Antipathy towards engagement in commercial activity. Poor information on market opportunities.
	OPTION CREATION: Selecting commercialisation opportunities for evaluation as options.	Commercialisation opportunities from SCANNING process	Assessments of patentability, including patent database searches. Provisional patent protection. Experimental development & proof-of-principle development	Qualitative information on relative suitability for exploitation. Provisional patents.	Low but significant. Effectiveness rests strongly on nature and extent previous experience of subsequent stages. Funding for provision patenting.	Funding for proof-of-principle. Poor knowledge of competitive market intelligence.
	OPTION EVALUATION: Evaluating options in terms of cost-risk-return probabilities.	Preliminary business case from option creation stage.	Development of quantitative formal business case proposals involving technical feasibility studies, market research, industrial partner identification etc.	Quantitative cost-risk-return estimates &/or supporting qualitative information	Significant to major funding required to generate technical risk assessments, market forecasts etc.	Technical expertise and funding for developing a formal business case for investment.
OPTION EXPLOITATION PHASE	OPTION SELECTION: Selecting options with the best return on investment probabilities	Formal business case from option evaluation stage.	Decisions about which business cases to proceed with.	Comparative investment evaluations	Minimal	Lack of experience in decision-making and of long term outcomes of previous decisions (ie. feedback)
	OPTION OWNERSHIP: Securing intellectual property over the commercial options (includes secrecy-based forms of IP).	Records of invention sequences, lab books, data files etc.	Securing of IP (if not already achieved)	Full patents.	Significant to major funding for legal and technical expertise & patent fees etc.	Funding for full patent protection.
	OPTION EXECUTION: Translating an option into a closed deal	Long-term IP protection from option ownership stage.	Execution of partnership/licensing deals or new business formation processes	Legally-binding agreements, new legal entities.	Significant funding for legal and commercial expertise.	Capacity of expert commercialisation professionals to work on deals given other commitments

Notes: the term 'option' is used here in the non-financial sense to refer to *possible* commercialisation activities. Nevertheless it shares the same fundamental properties as a financial option in the sense that an option can be exercised, or not exercised, depending upon future states of the world and information about these states of the world.

Static versus Dynamic Effectiveness

By drawing an analytical distinction between *static effectiveness* (matching policies and procedures only to current circumstances) and the *dynamic effectiveness* of this match (allowing them to evolve to a more favourable state), we have specified potential situations in which optimising static effectiveness can damage the potential for dynamic effectiveness. Moves to facilitate start-up firms that will help to change a university's external business environment, reflect a strategy of prioritising dynamic effectiveness. Although it is more risky, costly and takes longer to set up, the long-term benefits in the co-evolution of the university and its industrial 'constituency' may be considerable.

In this sense, Australian universities' structural disadvantage (a relatively weak industrial base) may turn out to be highly beneficial in creating a distinctive new paradigm for research commercialisation. This is because the weak domestic industrial base makes it difficult to commercialise research via licensing arrangements, and the dis-benefits to Australia of licensing to overseas multi-nationals are clearly recognised. As a result, licensing tends to be a less feasible and less attractive option than in the US and the UK.

This helps to focus interest on new business start-ups, which in turn, helps to address the underlying weakness in the industrial base by creating a cohort of young science-based firms able to interact far more effectively with the science base – the virtuous cycle in action. State governments are supporting biotechnology initiatives and clusters precisely for this reason.

In conclusion, some of the leading research-based Australian universities are helping to define a *new paradigm* for research commercialisation that explicitly recognises Australia's unique combination of an advanced basic research capability and a weak industrial capability to translate these options into commercial success.

Whilst commercialisation via start-ups is a feature of activities in other countries it is not as necessary for universities and state governments to actively create the conditions for effective university-industry interaction because these conditions are more favourable. The Australian approach may evolve into a distinctive approach because of the efforts to develop *integrated and distributed* capabilities to scan research and to generate commercial opportunities.

Policy Implications

The main policy implications to emerge from this study are that sufficient funding should be provided for proof-of-principle activities in order to remove a major impediment to the operation of the effectiveness of the commercialisation learning-by-doing process within universities.

This learning process is already under-way and is leading to innovative approaches to handling research commercialisation, particularly in the integration of the scanning of research activities for possible commercial application into everyday university activities. The improvements in business process efficiency that this learning process will produce, in turn, should stimulate greater researcher interest in commercialising their research.

The strategy of generating an increased number of start-up firms in the bio-science field will significantly help to improve universities' business 'constituency' by producing cohorts of growing science-based firms better equipped to interact with universities across a broad spectrum of channels. This may include the capability for greater mobility of staff between industry and academia. This 'co-evolution' of university and industry capabilities promises to be a major pay-off to universities' current commercialisation efforts.

Government should therefore consider the adequacy of the level of funding available for proof-of-principle work against requirements, particularly in relation to the likely net public benefits to Australia of capacity-building in research commercialisation in the health and medical area. The leverage provided by the organisational learning process we have highlighted is likely to generate a significant public benefit relative to the cost of such support.

A range of new experiments is currently under-way within Australian universities designed to increase their effectiveness in, and return from, research commercialisation. These include:

- a much greater emphasis on growing start-up opportunities;
- decentralisation of IP scanning processes;
- transfer of ownership from institution to individual;
- abolition of monopoly of university commercial arms;
- direct equity investment by universities; and
- selection and pursuit of strategic commercialisation areas.

There is great opportunity for, and a premium on, shared learning in these endeavours. Every effort should be made to encourage such processes.

Appendices

Appendix A: Terms of Reference

Objectives

The purpose of this study is to:

1) Investigate the issues relevant to university researcher involvement in new business enterprises including barriers to researcher involvement in new business enterprises and, in particular, ability to hold equity, accept directorships and move between academia and industry; and

2) Examine existing and emerging practices, nationally and internationally, in order to identify best practice models which could then be promoted to the higher education sector as a whole. The use of case studies and examples is encouraged.

Issues

In conducting this study, the consultant is expected to:

- Provide an overview of international best practice in university researcher involvement in new business enterprises;
- Identify institutional structures and processes which may facilitate or act as impediments to researcher involvement in new business enterprises;
- Examine financial and other incentives, including opportunities for promotion, which may enhance involvement in new business enterprises;
- Describe any impact on staff mobility, either beneficial or detrimental, caused by increased opportunity to participate in new business activities;
- Consider the relevance of Intellectual Property policies of universities; and
- Describe the level of information available to university researchers about opportunities for involvement in business enterprises.

Appendix B: Health and medical R&D statistics

Expenditure on Research and Experimental Development

Inter-sectoral variations in the type of R&D performed provide an input measure that helps us to understand how scientific and technological capabilities differ across sectors. Australia's official statistics are amongst the best in the world, particularly in the level of detail available. It is therefore possible to put together profiles of R&D expenditure in the health and medical area as a whole, and for sub-sets of this expenditure.

Official R&D statistics are classified by 'field of research' (FOR) and by 'socio-economic objectives' (SOE). FOR classified data tell us about the scientific fields in which researchers are active. SEO classified data tell us what the intended end uses of the research are.
For our purposes SEO classified data provides the most accurate picture of Australia's health and medical R&D expenditure. Detailed breakdowns of Health and Medical R&D for 1996-97 as classified by SEO can be found in Appendix B.[20] The following table shows a top level view of the national health and medical R&D effort by performing sector and by type of R&D in millions of dollars. This is followed by a table showing the percentage breakdown of this R&D by performing sector and by type of R&D.[21] These inter-sectoral variations in the type of R&D performed are more easily grasped by considering the graph in figure 1 - in which pure basic research and strategic basic research have been combined.[22]

[20] It will be possible to construct an updated profile of health and medical R&D on July 24th when the remaining sectoral R&D reports for 1998 are published.
[21] These figures do not relate exactly to 'field of research' classified R&D because the latter includes research that has other end-uses than human health.
[22] Many researchers are unclear about the practical distinction between these two types of R&D when they complete the ABS's R&D Expenditure Survey forms.

Table 5: Total Health and Medical R&D in Australia by Performing Sector and Type of R&D, 1996-97

$m Current Prices	All health and Medical Research					
	Higher Education	Private Non Profit	State Research Organisations	Comm Govt. Research Organisations	Business Sector	Total
Pure Basic	62.52	32.44	30.70	1.19	0.59	127.46
Strategic Basic	122.03	46.59	52.06	9.92	5.50	236.10
Applied	199.76	35.18	81.81	9.58	31.60	357.94
Exp. Dev.	29.14	14.52	15.02	1.41	66.30	126.39
Total	413.46	128.73	179.59	22.11	104.00	847.88

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

Table 6: Percentage breakdown of total health and medical R&D in Australia by sector and type of R&D, 1996-97

Percent of total	All health and Medical Research					
	Higher Education	Private Non Profit	State Res Orgs	Comm Gov Res Orgs	Business	Total
Pure Basic	7.37	3.83	3.62	0.14	0.07	15.03
Strategic basic	14.39	5.49	6.14	1.17	0.65	27.85
Applied	23.56	4.15	9.65	1.13	3.73	42.22
Exp Dev	3.44	1.71	1.77	0.17	7.82	14.91
Total	48.76	15.18	21.18	2.61	12.27	100.00

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

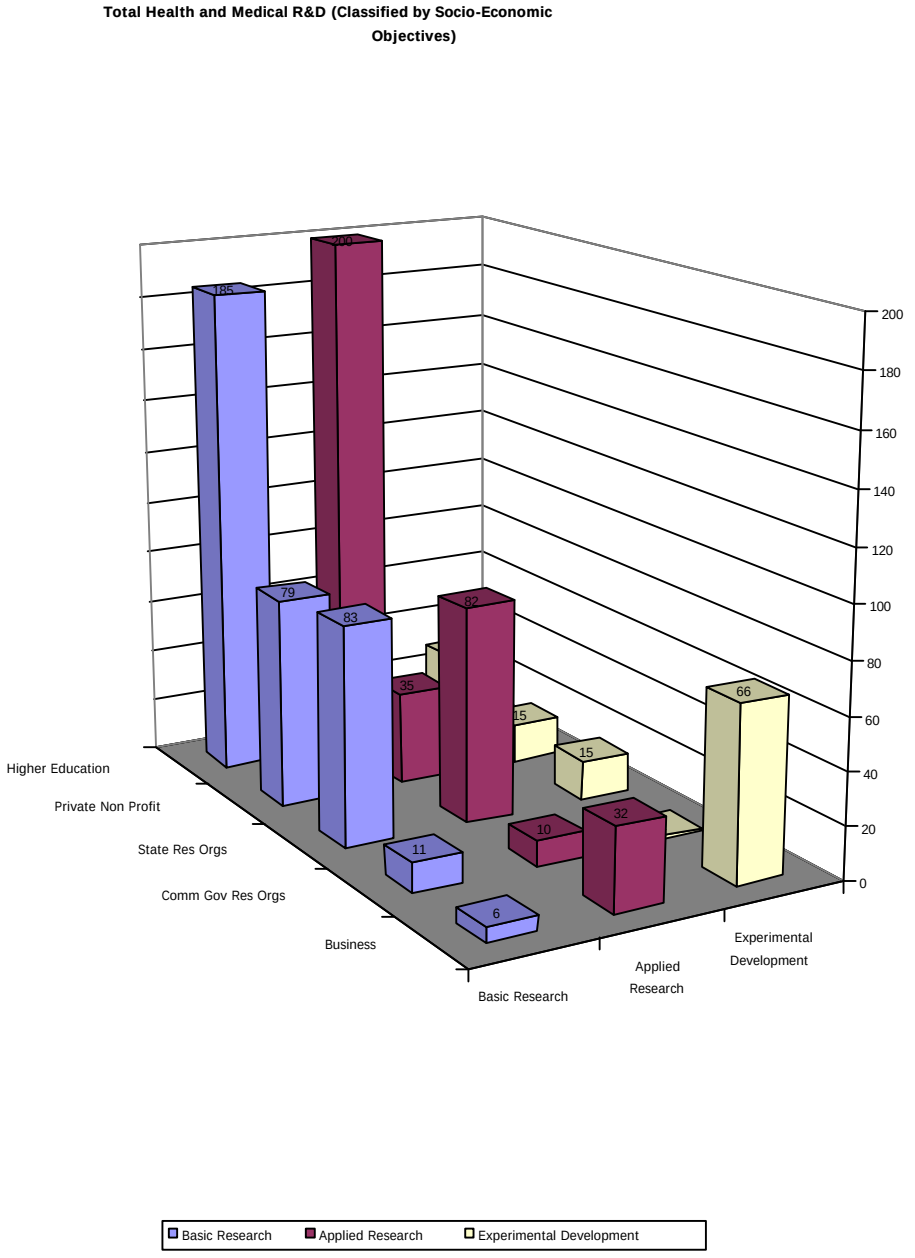


Figure 6: Health and Medical R&D in Australia by Performing Sector and Type of R&D

The dominance of the higher education sector in health and medical R&D is clear, as is the significant role played by the state government and private non-profit sectors. [23] What also stands out, however, is the relatively low level of business sector R&D expenditure, particularly in basic and applied research. The levels of expenditure on experimental development are of critical importance because they cover the activities required to translate laboratory findings into real applications in he form of drugs, instruments and materials. For example, clinical trials

[23] This is a characteristic specific to health and medical R&D, mainly due to the high level of charitable donations made for health and medical research and the role of stage governments in funding public hospitals.

undertaken to determine the efficacy of a newly developed drug are included as experimental development. However, if the trial is to obtain approval for the use in Australia of a drug already approved overseas, then it will not be considered as part of R&D.[24]

In general terms basic research generates knowledge of fundamental properties, applied research translates this fundamental understanding into options for possible exploitation and experimental development determines which of these options are practically and commercially viable. The processes involved in experimental development are usually far more costly than the basic and applied research that 'feeds' these processes. It follows that levels of experimental development activity are a key indicator of the extent to which there is investment in attempting to exploit the options generated via basic and applied research.

These R&D expenditure figures indicate that levels of experimental development expenditure are low compared to levels of basic and applied research expenditure in all R&D performing sectors. Some care needs to be taken in interpreting relative expenditure levels by type of R&D for specific SEOs and FORs. This is because basic research, in particular, involves exploring a wide range of research avenues whereas experimental development (as option assessment and exploitation) involves spending a lot more money on a relatively narrow range of avenues.

However, these top level R&D expenditure figures combine medical and health R&D. It is therefore useful to separate medical from health R&D. This is done in the following tables and graphs.

Table 7: Clinical R&D in Australia by Performing Sector and by Type of R&D, 1996-97

$m	Clinical R&D (Organs, Diseases and Conditions)					
	Higher Education	Private Non Profit	State Res Orgs	Comm Gov Res Orgs	Bus.	Total
Basic	142.1	67.0	58.8	5.1	4.0	277.0
Applied	94.8	22.6	49.8	4.0	23.3	194.6
Experimental Development	21.9	12.5	8.1	0.5	56.5	99.5
Total	258.8	102.1	116.7	9.7	83.8	571.0

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

[24] Advice on interpreting R&D data obtained from the Australian Bureau of Statistics. Due the 'grey' areas in the relationship between clinical trials and the standard international OECD/'Frascati' definitions of R&D activities revised classification guidelines are currently being drawn up.

Table 8: Percentage Breakdown of Type of Clinical R&D by Performing Sector, 1996-97

Percent of Sector Total	Clinical R&D (Organs, Diseases and Conditions)					
	Higher Education	Private Non Profit	State Res Orgs	Comm Gov Res Orgs	Business	Total
Basic	54.9	65.6	50.4	52.9	4.8	48.5
Applied	36.6	22.2	42.7	41.6	27.8	34.1
Experimental Development	8.5	12.2	6.9	5.6	67.4	17.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

Table 9: Percentage Breakdown of Total Clinical R&D in Australia by Performing Sector and by Type of R&D

Percent of total	Clinical R&D (Organs, Diseases and Conditions)					
	Higher Education	Private Non Profit	State Res Orgs	Comm Gov Res Orgs	Business	Total
Basic	24.9	11.7	10.3	0.9	0.7	48.5
Applied	16.6	4.0	8.7	0.7	4.1	34.1
Experimental Development	3.8	2.2	1.4	0.1	9.9	17.4
Total	45.3	17.9	20.4	1.7	14.7	100.0

Source: Calculated by Policy Intelligence using unpublished data specially provided by the ABS.

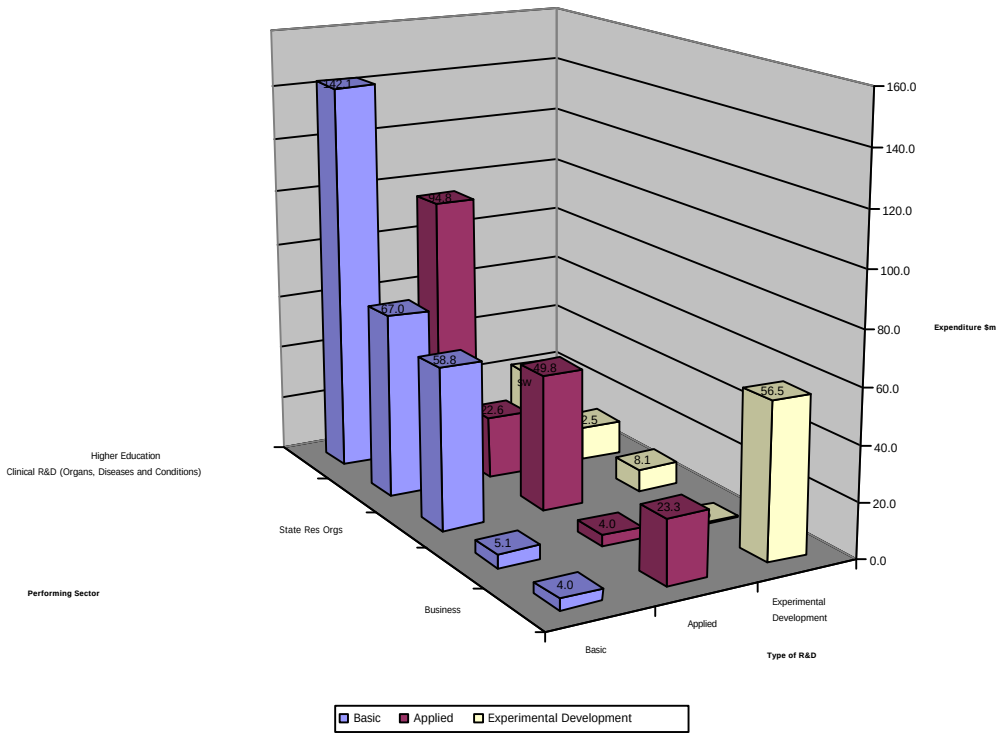


Figure 7: Clinical R&D by Performing Sector and by Type of R&D, 1997-97

At this lower level of aggregation the sectoral 'division of labour' in clinical R&D stands out fairly clearly, and (again) reveals that relatively little experimental development is performed when compared to basic and applied research, and that the bulk of this experimental development is performed in the business sector.

Although far more detailed R&D expenditure data is readily available for analysis, for example the following table provides the breakdown of R&D data available for clinical R&D, there are weaknesses in sectoral coverage. This is because this level of detail is not collected for the business enterprise sector (due to confidentiality restrictions) and some universities choose only to report their R&D to the ABS at the Clinical R&D level (and similar levels for health research). This means that more detailed R&D data for the higher education sector contains a mix of highly detailed and more aggregate figures.

Table 10: Detailed Breakdown of the Classification of Clinical R&D (Organs, Diseases and Conditions)

130100 CLINICAL (ORGANS, DISEASES AND CONDITIONS)
130101 Infectious diseases
130102 Immune system and allergy
130103 Blood disorders
130104 Neurological disorders
130105 Endocrine diseases (incl. diabetes)
130106 Cardiovascular diseases
130107 Inherited diseases
130108 Cancer and related disorders
130109 Surgical methods and procedures
130110 Respiratory diseases (incl. asthma)

130111 Hearing, vision and speech
130112 Oro-dental
130113 Digestive system
130114 Arthritis, bone and joint disorders
130115 Kidney diseases
130116 Reproductive medicine
130117 Skin and related conditions
130118 Other organs, diseases and conditions
130199 Clinical health not specific to particular organs, diseases and conditions

Source: Australian Standard Classification of the Socio-Economic Objectives of R&D

These R&D figures indicate that the relatively low levels of experimental development investment in health and medical R&D are an impediment to creating the virtuous cycle recommended by the Wills Review. This 'innovation progression gap' will tend to limit and guide universities' research commercialisation efforts.

Human Resources Devoted to Health and Medical R&D in Australia by Detailed Field of Research, 1998

Note: due to some universities only reporting to the ABS at sub-heading level (i.e. immunology as a whole) the detailed numbers are misleading. The most reliable figures can only be obtained at the sub-heading level.

Human resources devoted to R&D by Field of Research, 1998, (person years)				
		Researchers		
Field of research	Total	Academics	Postgraduates	Other supporting staff
100100 IMMUNOLOGY	53	14	28	11
100101 Allergy	33	8	16	10
100102 Cellular Immunology	149	38	80	31
100103 Humoral Immunology and Immunochemistry	47	14	26	7
100104 Immunogenetics	21	5	11	5
100105 Transplantation Immunology	59	17	27	15
100106 Tumor Immunology	37	9	19	9
100199 Immunology n.e.c.	88	29	41	18
100200 MEDICAL BIOCHEMISTRY AND CLINICAL CHEMISTRY	18	5	9	4
100201 Clinical Chemistry	12	5	6	2
100202 Medical Biochemistry: Carbohydrates	6	2	3	1
100203 Medical Biochemistry: Lipids	26	4	13	8
100204 Medical Biochemistry: Nucleic Acids		3	3	

	8			3
100205 Medical Biochemistry: Proteins and Peptides	78	24	37	17
100299 Medical Biochemistry and Clinical Chemistry n.e.c.	62	18	26	17
100300 MEDICAL MICROBIOLOGY	14	7	0	7
100301 Bacteriology	80	23	40	17
100302 Parasitology	62	18	32	12
100303 Virology	59	17	31	11
100399 Medical Microbiology n.e.c.	13	4	7	2
100400 PHARMACOLOGY	44	19	17	8
100401 Basic Pharmacology	161	69	68	25
100402 Clinical Pharmacology and Therapeutics	190	59	83	48
100403 Toxicology	73	15	39	19
100499 Pharmacology n.e.c.	92	37	27	28
100500 PHYSIOLOGY	82	26	40	15
100501 Human Biophysics	49	18	27	5
100502 Cell Physiology	174	58	78	38
100503 Systems Physiology	113	40	56	17
100504 Comparative Physiology	27	9	13	5
100599 Physiology n.e.c.	59	15	33	11
100600 NEUROSCIENCES	57	23	13	21
100601 Autonomic Nervous System	108	51	35	23
100602 Central Nervous System	227	80	108	38
100603 Peripheral Nervous System	31	11	11	9
100604 Cellular Nervous System	20	8	8	4
100605 Sensory Systems	107	39	46	22
100699 Neurosciences n.e.c.	104	33	53	18
100700 CLINICAL SCIENCES	223	68	108	47
100701 Anaesthesia	33	12	16	6
100702 Dermatology	22	7	11	4
100703 Cardiology	100	30	56	15
100704 Dentistry and Oral Surgery	148	52	80	16
100705 Endocrinology	227	83	119	25
100706 Foetal Development and Medicine	44	17	20	8

100707 Gastroenterology and Hepatology	103	37	51	15
100708 Geriatrics	27	8	13	7
100709 Haematology	95	23	45	27
100710 Intensive Care	5	2	3	0
100711 Infectious Diseases	53	14	25	14
100712 Medical Genetics	23	7	11	5
100713 Nephrology and Urology	49	17	20	11
100714 Neurology and Neuromuscular Diseases	64	18	27	19
100715 Obstetrics and Gynaecology	98	28	44	26
100716 Oncology and Carcinogenesis	175	40	63	71
100717 Opthalmology and Optometry	202	62	80	60
100718 Orthopaedics	79	21	41	17
100719 Otolaryngology	27	14	13	0
100720 Paediatrics and Child Health	160	49	85	26
100721 Pathology	141	36	80	25
100722 Psychiatry	246	87	109	50
100723 Psychology - Clinical	209	50	128	32
100724 Radiology and Organ Imaging	31	7	19	6
100725 Radiotherapy and Nuclear Medicine	11	4	6	1
100726 Rehabilitation and Therapy: Occupational and Physical	124	32	79	13
100727 Rehabilitation and Therapy: Hearing and Speech	63	12	41	9
100728 Reproduction	80	24	31	25
100729 Respiratory Diseases	51	13	29	9
100730 Rheumatology and Arthritis	65	28	29	8
100731 Surgery	129	39	68	22
100799 Clinical Sciences n.e.c.	242	61	146	35
100800 PUBLIC HEALTH RESEARCH	119	29	35	54
100801 Environmental and Occupational Health and Safety	137	43	63	31
100802 Epidemiology and Health Information Systems	218	74	96	48
100803 Mental Health	91	38	30	23
100804 Nutrition	111	29	59	23
100805 Preventive Medicine	99	24	49	26
100806 Primary Health Care		36	150	

	213			27
100899 Public Health Research n.e.c.	379	128	174	77
100900 HEALTH SERVICES RESEARCH	42	12	18	13
100901 Human Bioethics	8	2	5	1
100902 Health and Community Services Research and Evaluation	173	43	57	72
100903 Health Care Administration	29	8	12	10
100904 Health Education and Promotion	87	27	39	21
100905 Nursing	304	114	152	37
100999 Health Services Research n.e.c.	123	41	53	29
109900 OTHER MEDICAL AND HEALTH SCIENCES	49	22	9	19
109901 Biomechanics	70	12	54	4
109902 Medical Biotechnology	23	11	10	2
109999 Medical and Health Sciences n.e.c.	216	50	125	41
TOTAL Medical and Health Sciences	**8,482**	**2,619**	**4,092**	**1,772**

Source: unpublished data specially provided by the ABS to the NHMRC and made available to the consultants.

Appendix C: University Case Studies

Melbourne University

This case study examines one of the most radical shifts in the approach and policies to manage and promote commercialisation of research in Australian universities.

1. History
   There has been considerable upheaval and restructuring of arrangements for commercialisation of research in the past five years, via the successive granting of prime responsibility to UniMelb Ltd, MRE Ltd and MEI Ltd. This has led to a climate of instability. Staff generally found little assistance from previous arrangements.

2. New administrative arrangements
   From January 2000, new organisational arrangements for managing a program of professional services designed to foster innovation, protect and manage IP and facilitate contract and collaborative R&D were introduced. These involved separating the responsibilities of:
   - A Research Innovation and Development Group, within Melbourne Research and Innovation Office, responsible for negotiation of R&D contracts, facilitating a culture of innovation (including through advice and training on IP), and advising staff about avenue for development and commercialisation of IP, including referral to MEI or alternative external commercial specialists; and
   - Melbourne Enterprises International (MEI) Ltd, through its Business Development Division, responsible for managing existing IP portfolio, consulting management, facilitation of new business development opportunities and commercialisation of IP in strategic areas.

3. MEI has been provided with a budget of $30M (proceeds of the Melbourne IT float), with a requirement to produce a return of 6-8% pa, to be used to fund salary increases. MEI has no exclusivity, and has placed a Business Development Office in most Faculties to pursue business. Recognising the limited financial resources of staff and Departments, these services will be predominantly provided in return for an agreed percentage of the potential outcome.

4. A new IP Statute was approved by Council in December 1999 and implemented in May 2000. Under this arrangement IP rights and responsibilities reside with staff, not the University. Returns, after payment of direct costs incurred by the University, are 95% to the staff member(s) and 5% to the University for less than $1million and 85%/15% for more than $1million.

5. A variety of reasons have been provided for the change to the IP Statute:
   - influence of the model of the University of Toronto;
   - the Vice-Chancellor's driven to internationalisation of the University;
   - influence of a group of Melbourne academics who had experience and interests in facilitating commercialisation;
   - the potential to build a larger IP portfolio, associated with, rather than owned by, the university; one view is that the University's share of total IP exploitation may be smaller, but in total may be larger because of the larger volume of exploitation resulting from these new policies;
   - to get stronger commitment to commercialisation among academic staff;
   - to foster a new generation of wealthy alumni who may become substantial benefactors to their alma mater.

6. IP Training
   The University of Melbourne School of Graduate Studies is part of a consortium developing content for seven one-day courses on various aspects of IMP management, funded by the Victorian Government.

7. Views of Researchers

- The new arrangements, with responsibility falling to researchers to pursue commercialisation, may deter some staff.
- There is a danger that commercially naive researchers may be 'taken to the cleaners' by sharp commercial operators
- Without the backing of the University 'brand name', it may be difficult to attract and negotiate good deals.
- A recommended strategy would encourage researchers to form critical mass units in high commercial potential areas; the ultimate aim would be to form a company, but the first 3 years would be spent developing commercial, adequately protected, IP. Then would be the time to look for the right structure to commercialise the IP.

University of Sydney

The University of Sydney operates what could be described as a traditional university approach to research commercialisation. As noted in Chapter 3, the processes established place considerable responsibility on the researcher.

The commercial arm is the Business Liaison Office, which operates as part of the university and reports to the Pro-Vice Chancellor Research. The BLO is 'responsible for everything to do with commercialisation, contracts and consultancies' and has a staff of eight. It is organised into two groups: business development/contracts and the Intellectual Property and Licensing Unit.

Operations are highly centralised, though the Director and two Assistant Directors take responsibility for specific discipline areas. The Director is a bio-scientist with significant industry experience.

In the few years of its operation under the present Director, the BLO has come to be regarded as an effective and influential shaper of both policy and practice with regard to research commercialisation in the university. It has produced what is widely regarded among commercial arm managers as the best Manual in the country to guide researchers, which is updated every year. It also has produced a series of standard models for contracts, licences and other agreements. It also rune regular courses on IP and legal contracts.

New patent applications were made for 48 new inventions in 1999 compared with 14 in 1996. Licensing income has increased from $300,000 to $1.1 million over the same period, and will exceed $1.8 million in 2000. These are very substantial increases. However this increased licence income still accounts for only 3% of the total value of all research agreements. Research contracts are still by far the greatest source of industry revenue.

However satisfaction with BLO and its processes is not universal. There is a common complaint that the "researchers have to do all the work, for very little reward". Another problem is seen in its centralist operations, which makes it difficult to establish and maintain close contact with what is going on in the Faculties and Departments. To counter this problem, the Medical Faculty is employing part-time consultants to enhance awareness of research commercialisation opportunities and to scan and screen for potential developments.

While the formal emphasis of research commercialisation is on establishing licenses, there has been a significant emphasis, growing strongly in the past two years, on facilitating start-up ventures. Opportunities for spin-off companies are seen as increasing as more funds become readily available in the investment community for early stage ventures.

Perhaps the best known of Sydney University’s spin-off companies is ResMed Inc, now recognised as one of Australia's leading successes in taking a health-related product to the global market. It originated in research to develop non-invasive treatment for obstructive sleep apnoea at the University of Sydney in the 1980s. It now has net revenue in excess of US$80 million, and distributes to more than 80 countries.

Between 1996-99, nine spin-off companies based on university research were formed. The University has equity in three of these – eBioInformatics Inc., Benthic Geotech Pty Ltd and Australian Photonics Pty Ltd.

In 2000, four companies have been formed to commercialise medical related technologies developed within the university. In addition, in the last two months, two separate companies have been formed to commercialise the University intellectual property relating to eye disease and diagnosis. One of these has received approval for a Comet grant. Two other new companies have been formed in the last month, one to develop and commercialise a health product and one to commercialise plant varieties, both of which have approved Comet funding.

Clearly there is a rapid rate of growth, reflecting both the investment environment and a growing confidence based on accumulated experience (learning by doing) in new venture formation.

University of Queensland

The University of Queensland's administrative arrangements for handling technology transfer and research commercialisation have been documented in some detail by Cripps et al, 1999. Consequently, our objective is this case study is the build upon, rather than duplicate, this previous analysis by selectively highlighting and commenting on the aspects of the University of Queensland's arrangements that are pertinent to best practice.

General observations on motives, organisational structures, rules and regulations concerning research commercialisation

As with most, if not all, Australian universities the main motive for facilitating research commercialisation is to generate external private income to augment public sector income sources. A particular emphasis is placed upon forming start-up companies.

The University's research commercialisation firm, Uniquest Pty Ltd, has a monopoly over intellectual property protection arrangements and their exploitation, except (as is usually the case) for copyright other than software. It is university policy to take an equity stake in spin-off companies - though this involvement is passive and these firms are free to operate autonomously, (Cripps et al, 1999).

Collaborative research and funding arrangements are handled by the Research Office. Regular committee meetings involving the DVC (Research), Research Office and Uniquest, are held to determine how specific research contracts should be handled.

Consultancy work is encouraged and no overheads are levied unless university equipment and infrastructure are used. One day per week may be spent on such external work. Professional liability insurance is handled by Uniquest, although approval from department heads or centre directors is required for other arrangements in order to manage research and teaching loads, (Cripps et al, 1999).

Returns on the exploitation of IP are distributed on the basis on 1/3 to the inventor, 1/3 to the inventors centre/department and 1/3 to Uniquest.

The Move towards distributed and integrated commercialisation capacity

The most notable feature of the University of Queensland's arrangements for handling technology transfer and research commercialisation (TT-RC) is its recently developed strategy of distributing the TT-RC capability throughout the university. This strategy is based upon recognising the importance of *integrating* research, teaching and TT-RC activities in order to achieve stronger interactions between the three functions.

The university's new Institute of Molecular Bioscience (IMB) exemplifies this strategy. Staff performance is to be appraised on the basis of equal weighting for all three activities and a new research commercialisation company (IMBcom) has been formed to facilitate this integrated process.

More generally, the university's core research commercialisation company, Uniquest Pty Ltd, is in the process of recruiting commercialisation experts to be located in key faculties. These experts work from an office in the faculty and liaise closely with the Dean and academic staff and post-graduate students over the dissemination and commercialisation potential of current and planned research.

Learning-by-doing in research commercialisation

This aspect of the University of Queensland's approach has evolved in response to the learning-by-doing process that has taken place since the formation of Uniquest in the mid 1980s. The university has allowed Uniquest itself to go through a new business start-*up* process by recognising that a significant time-lag is required before returns on investment are achieved. This growth and learning-by-doing process is now poised to generate major financial yields that will provide investment funds for expanding the university's *capacity* and *capability* to facilitate research commercialisation.

Expanding *capacity* is important because there are limits to the size of the deal flow that can be handled at critical points in the negotiation process. Although it is possible for a research commercialisation arm to handle a large portfolio of deals, as they move through the commercialisation 'life cycle' the human resources required to close deals (a sub-set of the wider portfolio) restricts the number that can be brought to satisfactory conclusion. It is consequently essential that revenue from previous commercialisation deals be used to expand the capacity at these critical stages in the negotiation process by hiring skilled staff.

If this capacity expansion does not take place, and capacity expansion plans are not communicated, then this capacity constraint can, itself, constitute a major impediment to research commercialisation. This is because researchers will expect that the critical stages in negotiations will be drawn-out, time-consuming and stressful and, as a result, impose major opportunity costs that will impact upon their research performance - particularly in terms of publications. Given that a decision made *now* to initiate the exploration of commercialisation opportunities may bring with it this future *opportunity cost* researchers will tend to avoid this pathway if they do not anticipate capacity constraints being reduced.

As Uniquest notes, the capacity to close commercialisation deals has strong critical mass elements and therefore warrants a degree of *centralisation* of this function. It is seen as far more efficient, and therefore effective in generating outcomes, to retain critical mass via a degree of centralisation in the capacity to close deals than to devolve this capacity throughout the university.

The second issue concerns *capabilities*. The high levels of tacit knowledge required for successful research commercialisation mean that investment in upgrading these capabilities is requited in order to address this expectations problem - for closely related reasons. If the expectation is that the decision to explore commercialisation opportunities may bring with it serious problems due to capability constraints in the business processes involved (appraising commercial potential, securing patents etc) then the decision may be made to avoid opening up this option in the first place.

The University of Queensland's approach appears to recognise this expectational effect by striving to create a virtuous cycle of learning-by-doing and re-investment in capacity and capability expansion. The move to *distributed and integrated* commercialisation capabilities - a move designed to increase the rate of *generation/capture* of commercialisation options - is a clear manifestation of this approach.

Unlike the capacity to close commercialisation deals, the capability to generate commercialisation options (ideas, concepts etc) can be devolved. Indeed, the increase in communication effectiveness achieved between researchers and commercialisation professionals alone is likely to generate a large increase in commercialisation opportunities that may eventually exacerbate the deal 'closure' capacity constraint problem.

What is particularly interesting in University of Queensland's approach is that it seeks to maximise the advantages, in *commercialisation option generation*. This is done by developing a distributed commercialisation function within the university whilst also maximising *business process efficiency* in crucial stages of the commercialisation through centralised 'critical mass' *capacity* to close deals. The rationale for this is that either centralising or devolving overall responsibility for both capabilities and capacity would be far less effective than developing the two-phases of decentralised option generation and centralised negotiation.

Seed funding for commercialisation projects is provided.

The evolution of the university's model is, however, at a relatively early stage and it remains to be determined just how effective such a model is. On the basis of the analysis in this study the anticipated outcome for the university is very positive.

Curtin University of Technology

Curtin University, with its origin as an Institute of Technology, has always had strong links with industry, and acknowledged the need to develop substantial revenue flows that are not dependent on the Commonwealth Government. Its major emphasis has been on developing revenue through international student programs, and in this it has been very successful (of the order of $100 million).

As a smaller university, with acknowledged weaknesses in such key research indicators as proportion of research higher degrees, staff with PhDs, and proportion of research active staff, the challenge is to determine an appropriate IP and research commercialisation policy. The present policy is substantially modelled along the common pattern described in Chapter 3, and produces a modest income through licensing, and has seen the formation of two spin-off companies.

The key questions posed are:

- Can we have an entrepreneurial university without supporting entrepreneurial staff activity?
- Can existing structures accommodate entrepreneurial activity, and if not, how should they be changed?

A number of components of a new approach have been proposed:

- a greater incentive for the limited number of researchers capable of generating commercialisable research output by a greater personal incentive/reward – up to two-thirds of the net return;
- appointment of a person with the relevant experience to manage the IP commercialisation portfolio;
- establishment of a small fund by the University Investments Committee to support the taking of equity in entities commercialising university IP;
- mechanisms to facilitate the establishment of business units, primarily concerned with managing consultancy and commercial development opportunities in areas of significant commercial opportunity; they will not be concerned with normal academic activities but will be expected to operate in close association with an academic unit.

Under this new model, Curtin University is not so much focussed on extracting the maximum value from the research activities of its academics, recruited for quite different purposes and according to quite different criteria. Rather, it is seeking to establish linked capabilities in areas identified as having high promise, with the explicit intention of generating and exploiting IP.

Such a proactive approach inevitably carries risks, but is probably the only way that a smaller university could ever be more than a marginal player in research commercialisation, and the revenue it can generate.

Appendix D: Survey Methodology and Results

The On-Line Submission Process

Methodology and procedures used

The on-line survey form contains the following components:

- A section designed to capture basic information on the respondent such as name, institution etc.
- A section designed to capture information on the extent of experience in research commercialisation in terms of the: research areas, target industry sectors; number of relationships to date; personal financial outcomes, and financial outcomes for the research team/laboratory.
- A section designed to capture information on the appropriateness of a range of different research commercialisation avenues and to assess whether current impediments to research commercialisation affect the preferred commercialisation avenues.
- A section designed to capture information on the relative strength of key impediments to research commercialisation.

The form used can be found in Appendix H.

The following table lists the research commercialisation avenues used in the on-line submission form.

Table 11: List of Research Commercialisation Avenues Used in the Submission Form

- Licensing of IP by direct deal with existing firm
- Licensing of IP by deal mediated by university commercialisation arm
- Contract or collaborative research for an existing firm
- Consultancy advice for an existing firm
- New joint venture involving an existing firm
- New independent start-up with university equity investment
- New independent start-up without university equity investment

Contract and collaborative research (the former involving risk born by the contractor and the latter involving shared risk), and consultancy work were included because these can be important channels for research commercialisation/technology transfer.

The following table contains a list of the impediments to research commercialisation used in the on-line form.

Table 12: List of Impediments Considered

Administrative
1 University regulations - constraints to taking up directorships
2 University regulations - constraints to holding equity
3 Limits to commercialisation activity caused by the University technology transfer office's monopoly over intellectual property deals
24 Uncertainty and confusion over University policies and whether or not they actually have to be followed.
25 University employment contracts
26 Superannuation practices
27 University promotion & staff retention criteria
28 Time available for research commercialisation given research, teaching and administrative burdens
Financial
29 General availability of funding for post-research activities such as 'proof of principle' and securing IP that are pre-requisites for significant commercial investment
30 Access to external investment funding for subsequent commercialisation activities (e.g. by Venture Capitalists)
31 Uncertainty about future government Research and Development funding availability
32 Insufficient share of financial rewards when the IP is owned by the University
Legal infrastructure
33 Lack of legal capability in the University to secure intellectual property within required lead times
34 Lack of legal capability in the University to secure intellectual property effectively
35 Insufficient general capability in Australia to rapidly secure defensible IP
36 Insufficient general capability to defend IP in order to obtain economic advantage
Cultural
37 Perceptions by research colleagues that commercial activities compromise academic reputation
38 General antipathy in Universities towards commercial activities stemming from research
39 Pressure from the University to secure intellectual property via patenting irrespective of the nature of the technology or the stage at which its development is at
Experiential
40 Insufficient previous personal experience of research commercialisation given the level of tacit knowledge required
41 Insufficient collective experience of commercialisation within the University given the level of tacit knowledge required
42 Insufficient access to external advisers with practical experience of commercialisation
43 Insufficient information available on basic commercialisation practices and procedures to offset a lack of personal experience

These impediments can be distinguished in terms of their *causality*. The *administrative* and *financial* impediments are, in a sense, independent variables in the sense that they block the learning-by-doing processes that determine the levels of the *legal infrastructure*, *cultural* and *experiential* impediments - the dependent variables.

This framework consequently allows us to distinguish between impediments that can be expected to reduce via learning-by-doing and the impediments that restrict the extent of learning-by-doing. It is the latter type of impediment that policy can, and should, focus on reducing or removing.

Submission Process

Once completed the data collected via the form is sent electronically to a database file for immediate analysis. Where necessary, the facility exists for respondents to be invited to re-examine their answers in order to deal with any problems and/or missing replies.[25] This has been done in cases where there have been missing values in the data-set.

The form has been designed to allow both university staff to respond *and* people in other sectors who may wish to submit their views on the problems faced within universities. The rationale for this is that commercialising university research often involves research collaborators or commercial partners in organisations in other sectors, notable the CSIRO, CRCs, private-non profit research organisations and of course business enterprises.

Notification of the existence of the on-line submission form has been achieved by:

- Email messages to senior university staff. In most cases PVC/DVC (Research) and/or Directors of Research Offices. These messages requested that the recipient forward the message to relevant people in the University.
- An information sheet handed out those who attended the series of Biotechnology Australia IP management seminars.
- An emailed letter sent by the acting CEO of the NHMRC to all universities, and also to other research organisation alerting people to the existence of the study and the on-line submission process.
- Contacting the CSIRO .
- E-mailing the CEOs, or equivalent of relevant CRCs.
- Arranging for the Australian Society of Medical Researchers (ASMR) to email all their (1100) members about the study and the on-line form.
- Arranging for the National Association of Research Fellows of the NHMRC to e-mail all their (183) members.
- Contacting the Directors of university research commercialisation firms/offices via an e-mail message.
- E-mailing the 1095 people who either made a submission to the Wills review, or commented on the draft report, for whom e-mail addresses were available.

Attempts were also made to arrange for the Licensing Executives Society Australia and New Zealand (LESANZ) to e-mail their members about the on-line submission process, and for a reference to the submission process to be made in a communication to those in the National Innovation Summit e-mail list. However, in these cases it did not prove to be possible to do this within the required time frame.

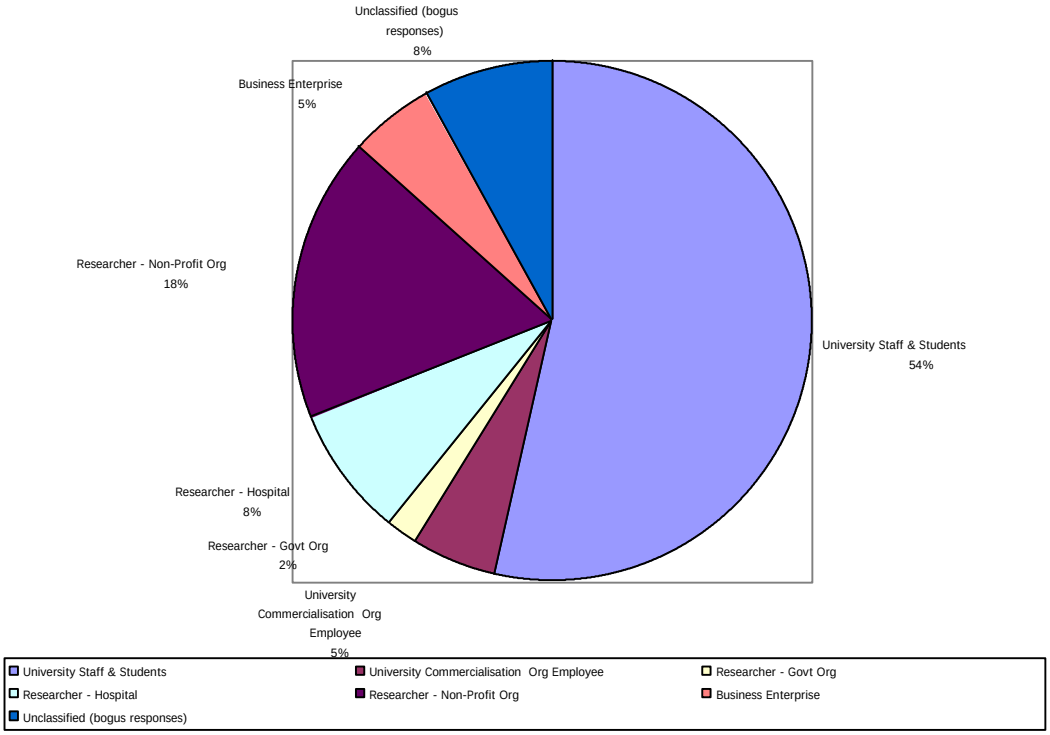
[25] This involves entering a serial and PIN number in order to access and modify the data on the database server.

Response obtained

As of 12 July 103 useable responses (out of 113 in total) have been received via the on-line form and 14 longer textual submissions from researchers who have completed the form. The results discussed below are based upon the 103 useable responses available for analysis.

The following pie chart shows the breakdown of these responses by the sector of the respondent.

Figure 8: Sectoral Breakdown of Responses



Just over half the responses are from university staff & students (primarily staff with a few graduate students). There have been six from staff in university research commercialisation arms. Responses from people outside of the higher education sector are dominated by researchers in the private non-profit sector and from researchers in hospitals.

The data-set has been be analysed with respect to sectoral location as two groups of respondents:

- university staff & students, and;
- and staff from university research commercialisation arms and all other respondents.

This division of the sample allows the characteristics of the responses from each sector to be compared in order to identify differences between the two sub-samples.

Three factors seem to be responsible for the current response rate:

- *general awareness*: the senior university staff contacted initially have not forwarded the message in many universities;
- *time constraints*: the period available for raising awareness, and for making a submission given other commitments may be too short (particularly as awareness takes time to increase within universities);
- *low levels of researcher interest:* the number of researchers with an active interest in research commercialisation may be low relative to the total number of researchers in relevant research fields.

Numbers of Researchers in the Health and Medical Area

The on-line form has been designed specifically for use by people with an active interest in research commercialisation. We have collected statistics on the level of interest in the study's web page (the pre-cursor to completing the on-line form) and there have been 841 'hits' by July 12th, the majority from academic institutions[26].

A very crude estimate would therefore be that something over 10 percent of those reading the background information on the study have defined themselves as having an active interest in research commercialisation *and* have gone on to complete the submission form. On the basis of anecdotal evidence this is not an unreasonable estimate of the proportion of researchers and in the health and medical research fields who may have an active interest in research commercialisation. It is not unreasonable to make such an assertion because most web-page readers are using computers located in the higher education sector.

The latest ABS R&D survey of the higher education sector identifies 2619 academic researchers in universities in 1998. A detailed breakdown of these numbers by field of research is provided in Appendix B

Although caveats apply to these figures the numbers of researchers in many different research fields are strikingly low.

This estimate of the 'population' of health and medical researchers puts the response to the on-line survey into context. There have been 60 responses from university researchers, ie 2.3% of the overall population of researchers. Given that only 5% of researchers may currently have an active interest in research

[26] As measured by the identification labels in permanent IP addresses (an identification scheme that allows web-page user profiles to be tracked and statistics on page use collected).

commercialisation (on the basis of anecdotal indications) we may have captured around half of the target sample.

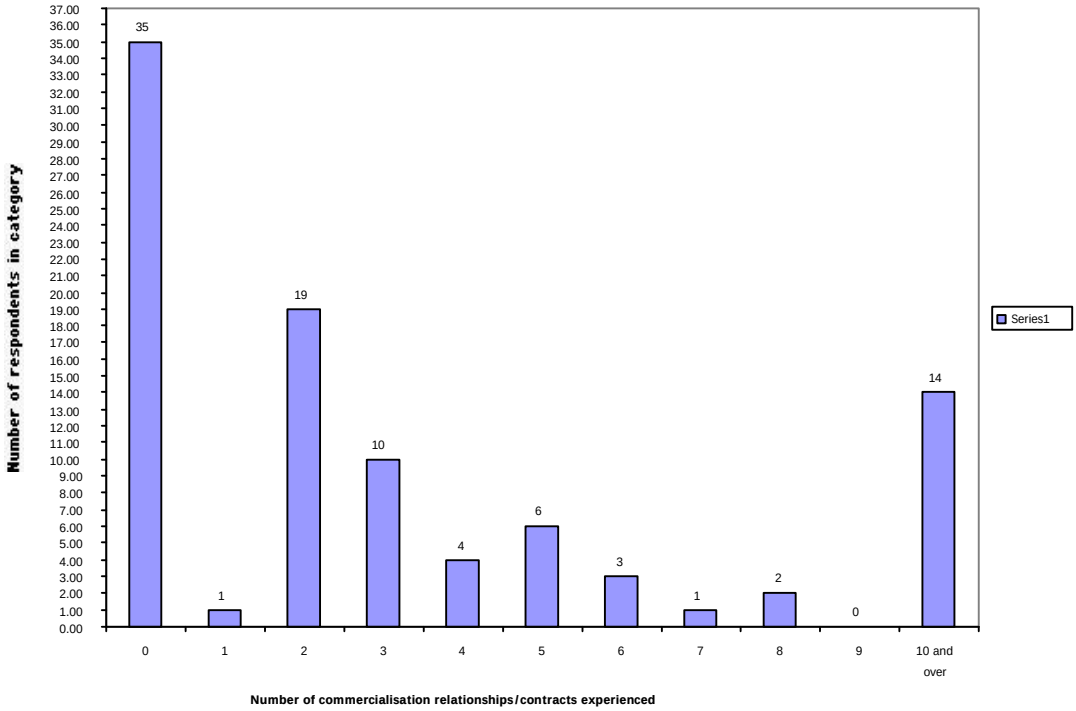
Findings from Consultations and Submissions

Levels of experience and commercial outcomes achieved

Levels of experience in research commercialisation are an indication of the level of tacit knowledge of these issues held by the respondents.

The following graph shows the variations in the extent of experience of research commercialisation across the sample, as measured by the number of commercialisation relationships or contracts engaged in to date.

Figure 9: Experience in Terms of Numbers of Commercialisation Relationships



Note: based on 103 submissions from a total sample of 113.

There are a large number of respondents (35) with no experience of actual research commercialisation relationships or contracts, and the extent of experience (measured in these terms) drops off fairly rapidly - though with 14 respondents being involved in ten or more relationships.

This implies that the views expressed on preferred research commercialisation avenues and the various impediments to research commercialisation are not, in general, based upon extensive experience *throughout the sample*, but nevertheless 68 out of 103 respondents who gave answers here (66%) do have some experience of research commercialisation.

Financial Outcomes from Research Commercialisation Activities

The submission form requested information on two aspects of the financial outcomes from research commercialisation activities: the value to the individual and the value to the team or laboratory under that individual's direction.

The results obtained are shown in the following two graphs.

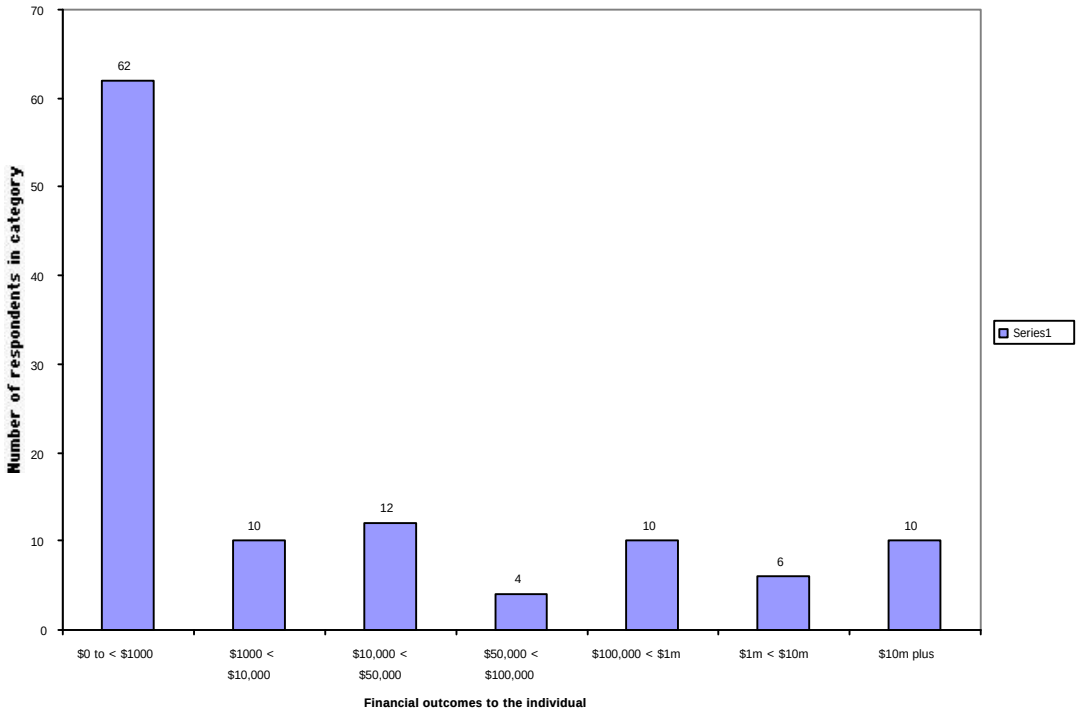


Figure 10: Commercial Outcomes for the Individual Respondent

Note: based on 103 submissions from a total sample of 113.

With respect to the value of financial gains to the individual researcher, and setting aside the relatively large number of zero gains associated with no actual commercialisation experience, there is a reasonably even spread of gains across the specified financial ranges.

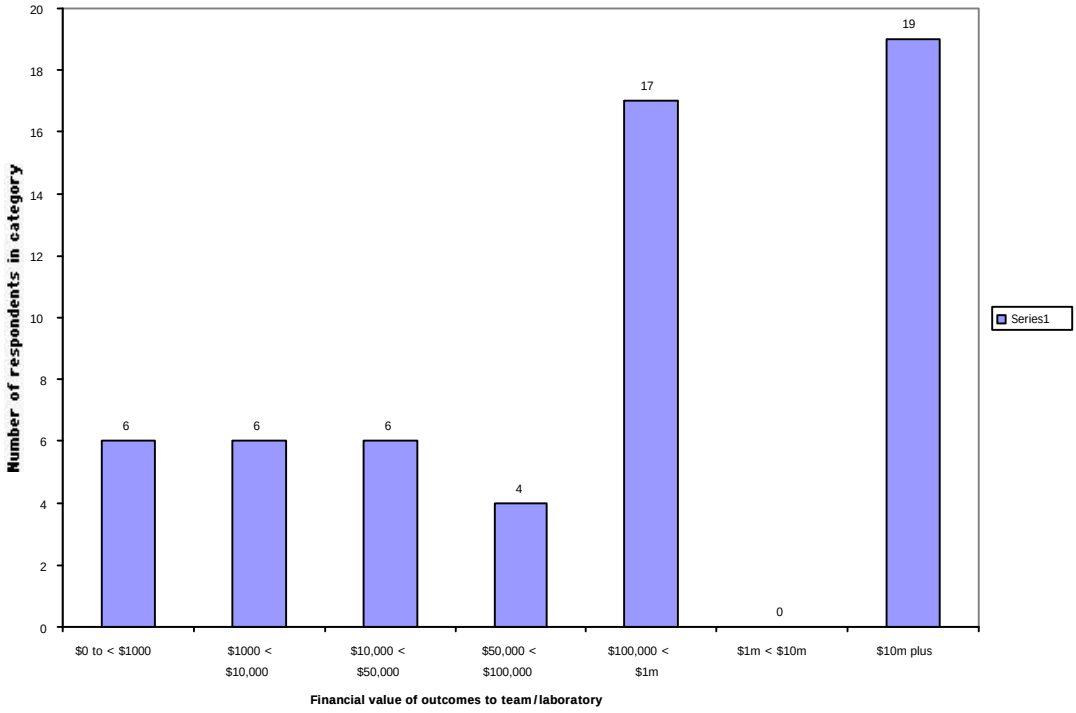


Figure 11: Commercial Outcomes for the Team/Laboratory Under the Respondent's Direction

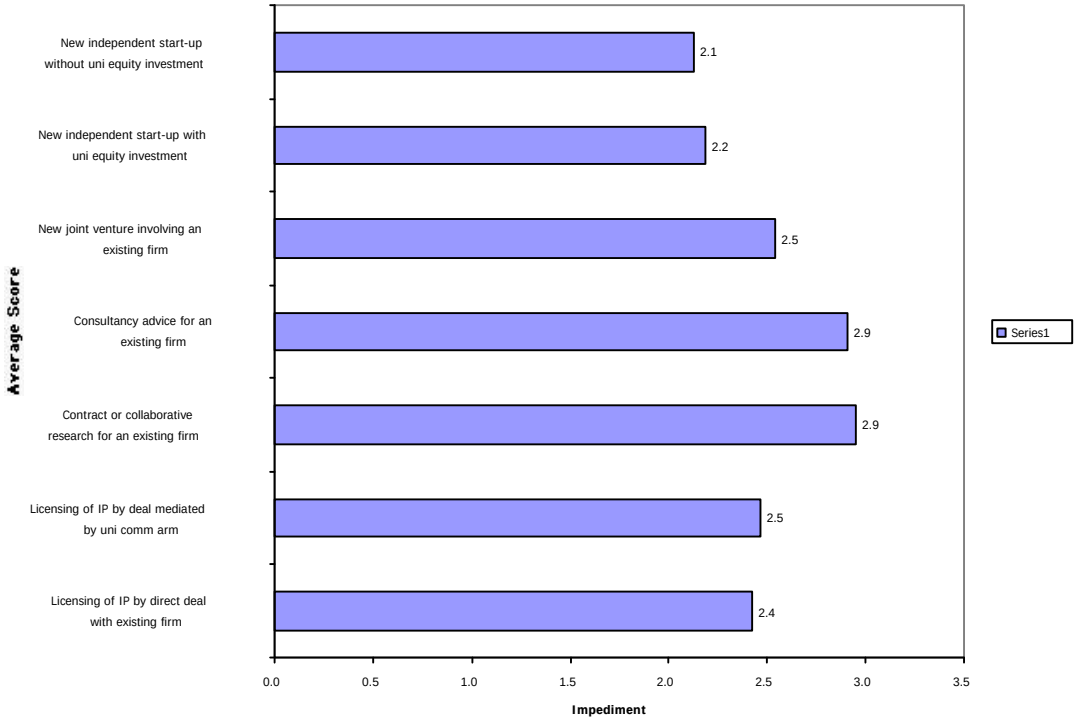
Note: based on 103 submissions from a total sample of 113.

Turning to the financial gains to the team/laboratory under the direction of the respondent we see that 36 respondents have been associated with securing financial gains of over $100,000 for their research groups.

Preferred research commercialisation avenues in Australia

The following graph shows how the respondents have collectively rated each of the research commercialisation avenues specified *with current research commercialisation impediments in place*. A score of zero to five was used, with the additional option of providing a 'no view' response. These averages exclude 'no view' responses.

Figure 12: Preferred Research Commercialisation Avenues



Note: based on 103 submissions from a total sample of 113.

These results indicate that the most preferred commercialisation avenues are contract or collaborative research with an existing firm and consultancy work for an existing firm.

These can be very effective mechanisms for technology transfer/collaboration when there are adequate industry '*receptors*' for the technology. These avenues are usually associated with incremental innovation as distinct from more radical scientific and technological advances - and the former advances are more frequently made than the latter.

It would be unwise to read any more into these results, save for noting that the least preferred avenues are new business start-ups, and that the general pattern of these results, suggests that the avenues with the best risk to effort ratio are preferred. Technology transfer via research & consulting linkages is relatively risk-free and does not attract the 'overhead time' effort and stress that licensing arrangements tend to require.

These results do validate the view taken by the study team in executing this research - that new business formation is not the primary or optimal technology transfer/research commercialisation mechanism in the health and medical area under current impediments.

It is important to compare the preferred research commercialisation avenues of university researchers with the views on appropriate commercialisation avenues

for university researchers expressed by other respondents. This is done in the following graph.

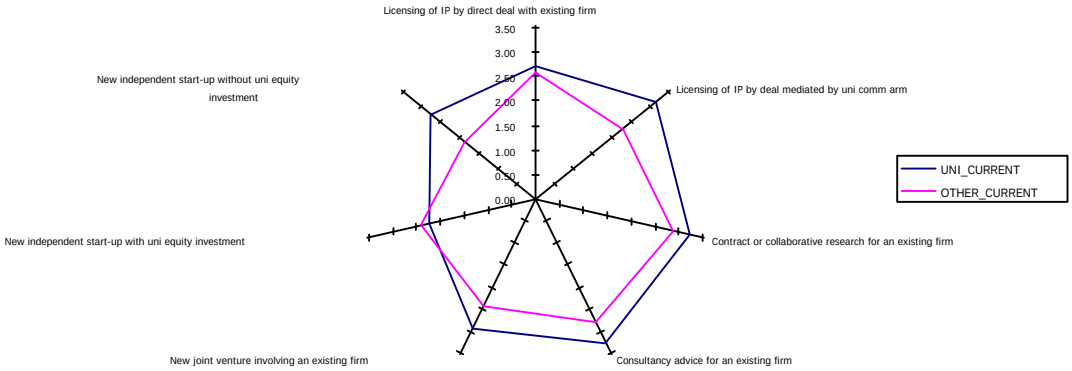


Figure 13: University and Non-University Views on Preferred Commercialisation Avenues Compared

Note: based on 103 submissions from a total sample of 113.

The two groups roughly agree about the applicability of:

- new independent start-ups with a university equity investment;
- contract and collaborative research;
- consultancy advice for an existing firm, and;
- new joint ventures involving an existing firm.

However, their views differ more markedly on:

- new independent start-ups without a university equity investment, and;
- licensing of IP via a deal mediated by a university commercialisation arm.

The impact of research commercialisation impediments on preferred research commercialisation avenues

We now turn to the results obtained on the impact of current research commercialisation impediments upon preferred research commercialisation avenues.

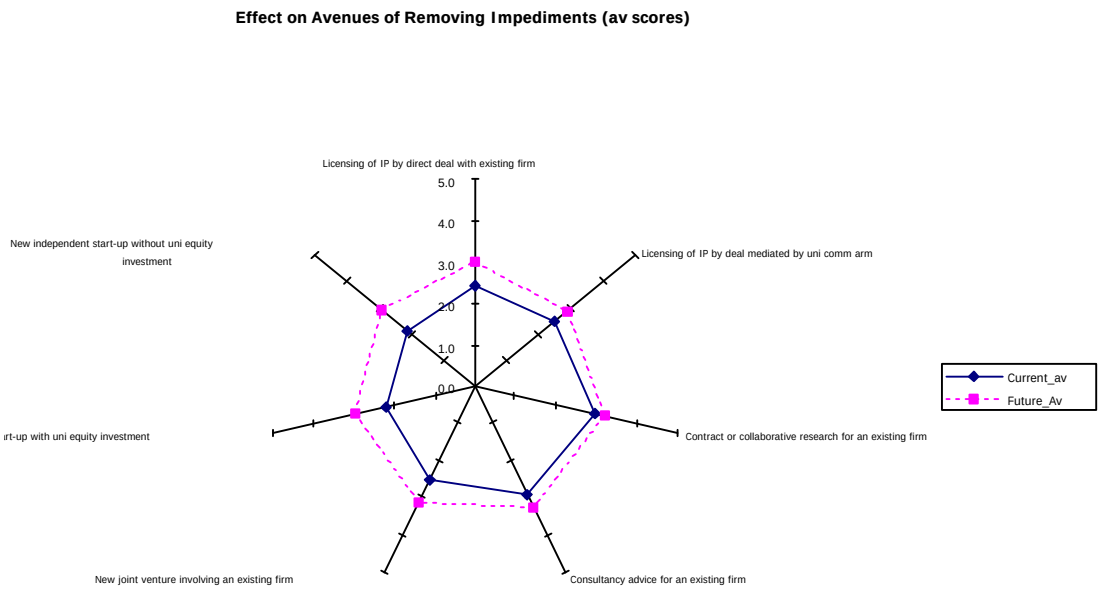
This question is pertinent to policy formulation because there is a view that a *broad spectrum* of university-industry interactions is more effective than a limited spectrum in closing the cultural gap between the two sectors - thereby facilitating the commercialisation process.

A broad spectrum of interactions tends to involve beneficial 'interactive' and knock-on effects between the different channels that raise the overall effectiveness of the process.

The submission form asked respondents to provide another set of ratings of the appropriateness of these commercialisation *avenues assuming that current impediments have been removed*. This question was designed to allow us to test whether or not current impediments affect preferred commercialisation avenues.

The following graph illustrates the impact of impediments on preferred commercialisation avenues by plotting both sets of scores on the 'spokes' defined by each commercialisation avenue. The unbroken line describes the current situation, the broken line the hypothetical impediment-free situation.

Figure 14: Effect on Preferred Research Commercialisation Avenues of Removing Current Impediments



These results suggest that current impediments *are* perceived to affect preferred research commercialisation avenues, and (assuming that preferences relate to actual activities) current impediments may have the effect of:

- limiting new firm start-up activity that involves university equity;
- limiting new firm start-up activity that *does not* involve universities making an equity investment;
- limiting activity that involves licensing IP via a direct deal with an existing firm;
- limiting joint ventures with existing firms.

The differences for contract and collaborative research, consulting and licensing deals mediated by university commercialisation arms are less marked.

In general, current research commercialisation impediments appear to restrict the 'breadth' of commercialisation activity - producing a 'less rounded' commercialisation profile.

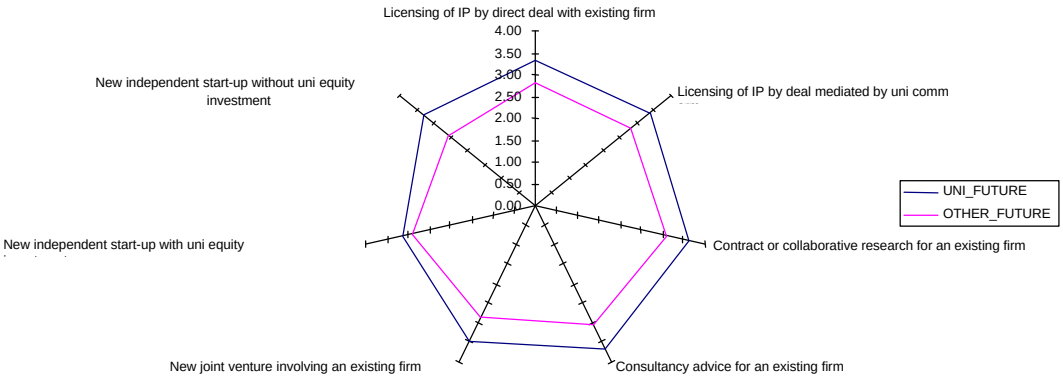


Figure 15: University and Non-University Perceptions of the Impact of Impediments Compared

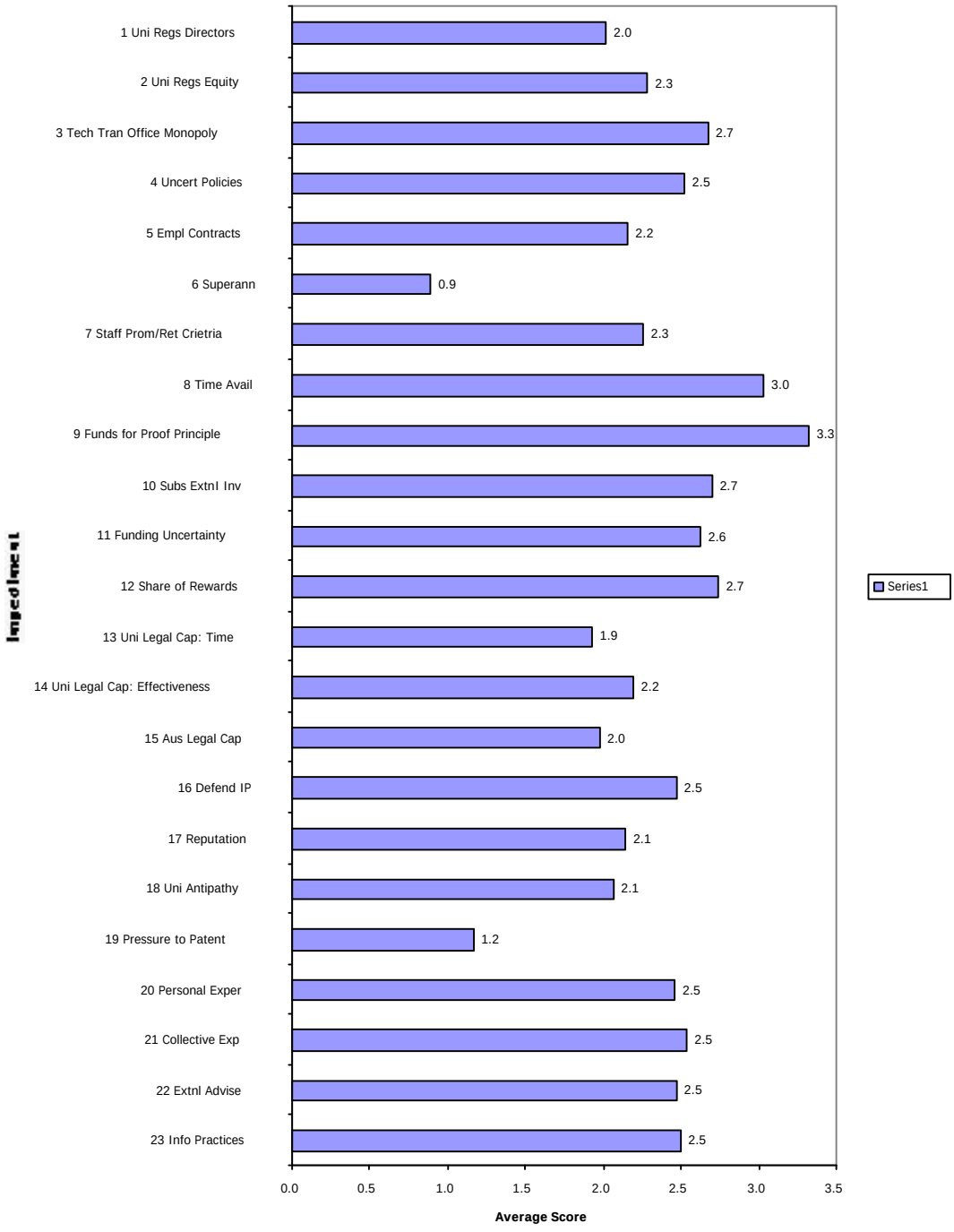
The two sub-samples broadly agree on the effect of removing current impediments to research commercialisation and are in most agreement over new independent start-ups *with* a university equity investment.

Impediments to research commercialisation in Australia

Finally, we consider the relative strength of a number of key impediments to research commercialisation.

The following graph indicates how these impediments were rated. The same 0 to 5 scoring system has been used as above, except that respondents were given the option of also selecting 'not applicable' in addition to 'no view'. In this context, respondents were asked to rate impediments in terms of relative severity in the impact upon levels of commercialisation activity. The average scores exclude the 'no view' and 'not applicable' responses.

Figure 16: Rating of Different Impediments to Research Commercialisation Activity



Note: based on 103 submissions from a total sample of 113.

On this basis of this sample the most severe impediment to research commercialisation is funding for 'proof of principle', with the time available for research commercialisation and the share of rewards that can be obtained and a university technology transfer arm monopoly over IP deals also featuring strongly.

Not surprisingly most of the impediments covered scored fairly highly, although superannuation policies and pressure to patent from the university irrespective of the nature of the technology and its stage of development do not feature strongly.

Note on the impact of university regulations

It is noteworthy that university regulations concerning the holding of directorships and equity, a problem highlighted in the Wills Review, do feature as significant impediments. This finding appears to contradict the view expressed by senior university staff (who set such policies) that these are not major impediments.

We obtained more information on this issue my contacting the 32 respondents who had given a significant score (of 3 or above) to these two impediments.[27] 15 respondents (just under half) replied within 24 hours and their responses allowed us to clarify this issue.

It turns out that these impediments were given significant scores as much because there is general dissatisfaction with the 'business process' efficiency with which universities handle a wide range of commercialisation matters as specific constraints caused by rules and regulations.

Differences in Impediments as Viewed by University-based and Non-university Based Respondents

We now consider how the views on the severity of these impediments to research commercialisation differ between university-based and other respondents. This can be seen in the following two graphs, the first of which shows the average score for each impediment by sub-sample in bar chart form, the second of which shows the relationship between the two sets of scores in scatter-gram form.

[27] This was done via an email message.

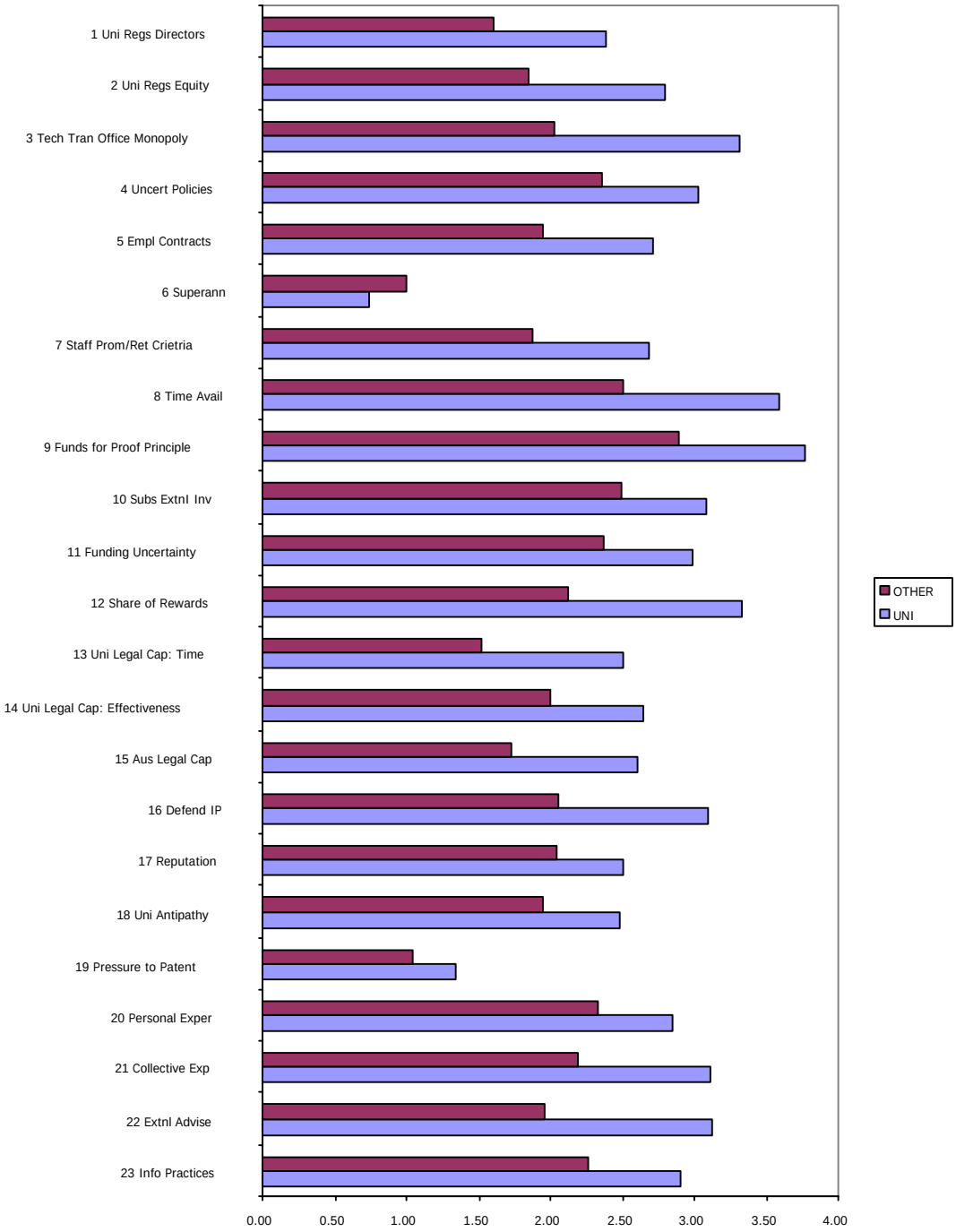


Figure 17: Rating of Different Impediments to Research Commercialisation by University and Non-University Respondents

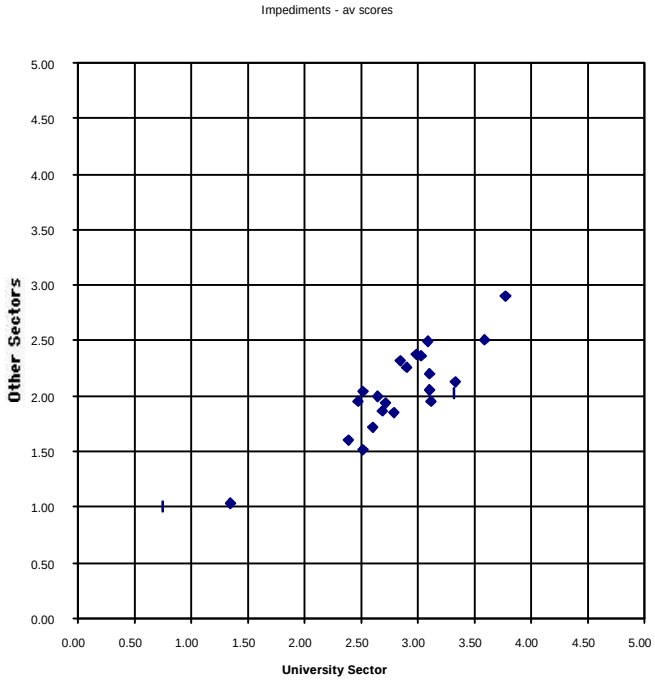


Figure 18: Relationship between University and Non-University Sector Scores for Different Impediments

It can clearly be seen in both graphs that the university-based respondents view these impediments as being of greater severity than do the outside observers. This is probably to be expected given greater familiarity of university staff with these problems. The close correlation between the two views is re-assuring in the sense that it helps to confirm that the two sub-samples agree on the relative severity of these impediments in the higher education sector.

Levels of Knowledge and the Applicability of Different Impediments

It is worth considering the incidence of 'no view' and 'not applicable' responses for each impediment because this tells us something about the level of knowledgeability of these issues and the prevalence of the various impediments.

The following graph shows the number of 'no view' and 'not applicable' responses for each impediment. It confirms that, in general, the two variables move together.

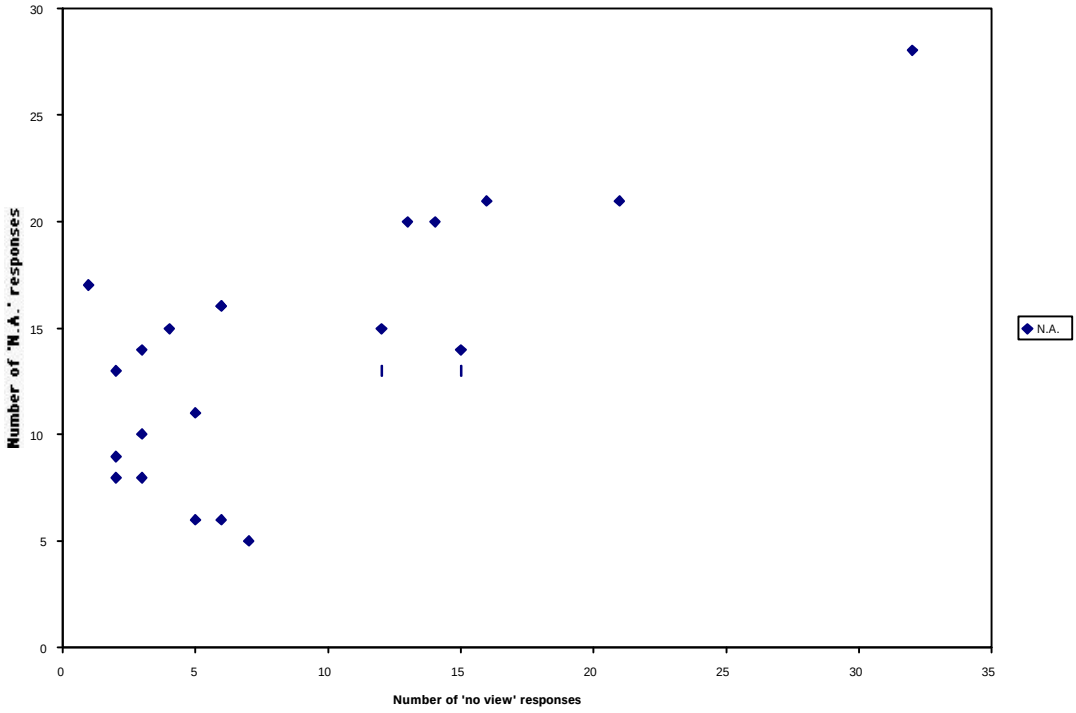


Figure 19: Number of 'no view' and 'not applicable' Replies Compared

The incidence of 'no view' and 'not applicable' responses is more clearly grasped in the following bar chart.

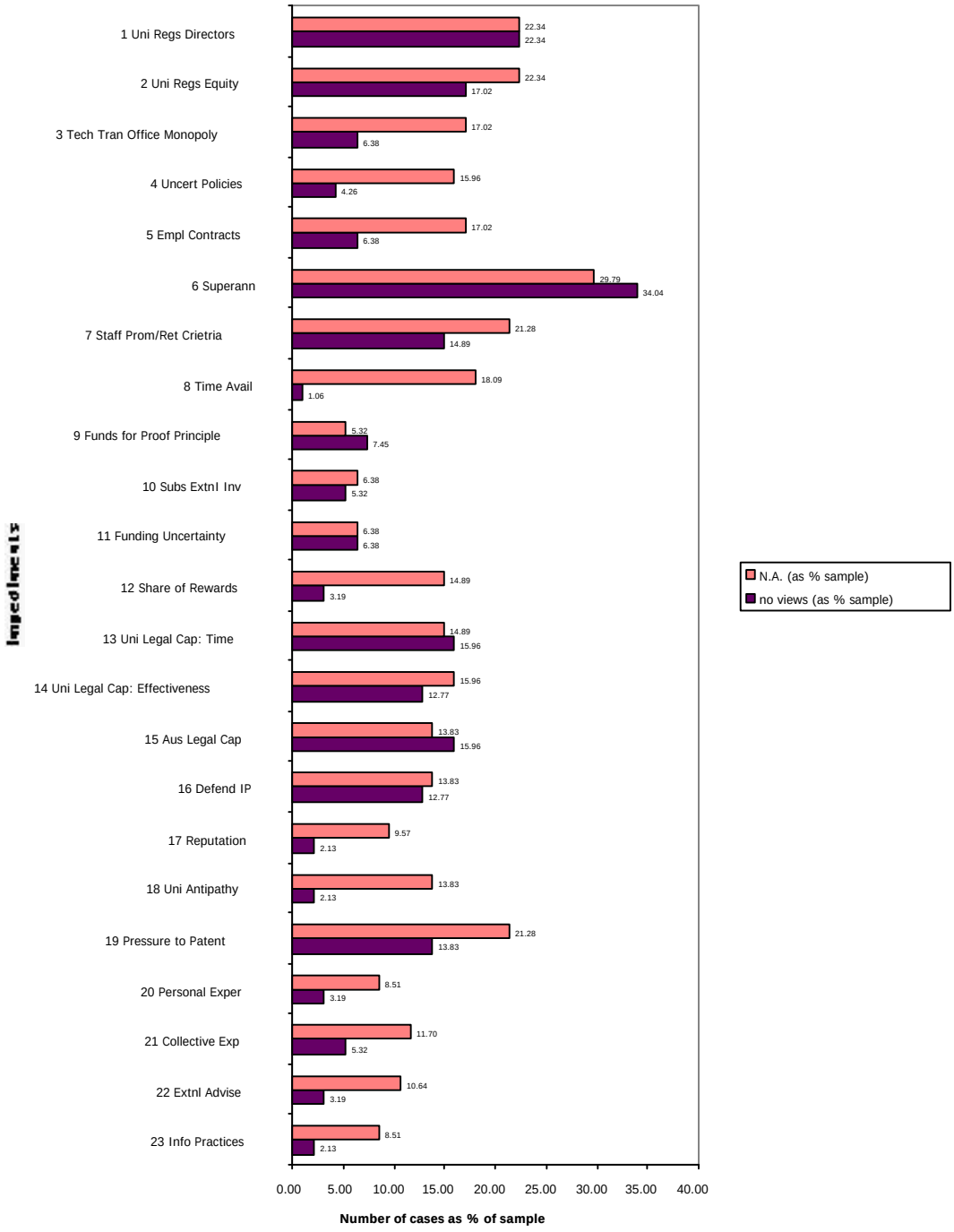


Figure 20: Percentage Incidence of 'no view' and 'Not Applicable' Responses for Each Impediment

These figures show that *superannuation policies* stand outs both in terms of non-applicability and no view being expressed. University regulations over holding directorships and equity exhibit relatively high incidences of low knowledgeability and non-applicability.

Concluding Comments on the Results from the On-line Submission Process

Researchers and other informed people, take a wide and considered view of the relative applicability of the various research commercialisation avenues that are available. In particular, they recognise that collaborative/contract research and consultancy work can be major channels for commercialisation.

This probably reflects the fact that many research results are too incremental to warrant commercialisation via a start-up company. This in an important point because is places Australia at something of a disadvantage vis-a-vis countries with more advanced innovation capabilities in the private sector because there is less scope for such university-industry interactions in Australia.

The major impediments to research commercialisation are the availability of funding for proof-of-principle activities and the subsequent investments necessary to produce cost-risk-return probabilities that will attract external investors. This funding problem is exacerbated by factors such as insufficient time available for dealing with research commercialisation given other duties and responsibilities.

Perhaps most importantly, the findings from both the on-line submission form and (far more strongly) from personal communications and the textual submissions received point very strongly towards a single generic problem that affects all the universities covered. This is the low level of business process efficiency exhibited by many universities and their research commercialisation arms in handling these procedures and decisions.

This finding compliments that of the various detailed case studies in that it highlights the impact of learning-by-doing in handling research commercialisation matters. This aspect of business process efficiency is driven by partly by the lack of cumulative experience gained from previous research commercialisation activities and partly by the tensions caused by the need for university administrators to operate in a new, more business-like environment than has been the case in the past.

These consultations have not revealed that there are 'internal' university policies and procedures that constitute direct barriers to research commercialisation. Instead, they have revealed that current impediments are, to a significant extent, driven simply by the need for more experience in research commercialisation - a process that will tend to improve business process efficiency within universities and their commercialisation arms.

If these current impediments were to be removed then a more rounded profile of research commercialisation activity would result- with more activity in all commercialisation avenues. This is likely to lead to beneficial knock-on effects that would play an important role in improving university-industry interactions in Australia.

Appendix E: Profiles of Arrangements for Handling Technology Transfer and Research Commercialisation in Selected Overseas Universities

The following draft profiles were prepared for the study by Craig Meer, a Policy Analyst at Policy Intelligence. Each profile follows a similar format summarising the:

- institutional arrangements;
- practices and procedures;
- experience and learning;
- copyright and intellectual property;
- appointment and enrolment practices, and;
- other regulatory prohibitions and caveats.

These are summarised in Table 13 below.

Table 13: Summary of Administrative, Regulatory and Legal Approaches at MIT, UCLA, Stanford and Oxford

Administrative Arrangements			Regulatory Provisions		
Name of Responsible Agency or Department	*Distinctive Features of Arrangements*	*Details of Institutional Learning*	*Copyright & Intellectual Property Policies*	*Appointment & Enrolment Procedures*	*Guaranteed Freedoms (of research, etc.)*

Stanford	Office of Technology Licensing.	OTL staffed with project, management and technical personnel, not bureaucrats or lawyers.	History of institutional design dating back to early 1970s.	Stanford claims right, title, and interest in IP & copyright produced by academic staff and students.	All University personnel required to sign SU-18: obliges full research disclosure.	Domaining right guaranteed, but unclear as to whe this may be exercised.
UCLA	Office of Technology Transfer	OTT not geared for performing incubator-style operations; does not pursue start-ups. Emphasis is on facilitation.	Current arrangements based on suggestions forwarded in 1994 review of practices.	UCLA claims right, title and interest in those inventions which *might be readily patentable*.	Paid staff required to sign Patent Acknowledgeme nt Form: obliges partial disclosure.	University privac policy may overr disclosure requis
MIT	Technology Licensing Office & Industry Liaison Office	TLO & ILO operate alongside dedicated technology transfer programs designed to build lasting alliances.	MIT pioneered the concept of industry liaison in 1948 with the founding of the ILO.	MIT affirms copyright law, & only claims IP from targeted or sponsored research, and 'work for hire.'	Personnel must sign Inventions and Proprietary Information Agreement: has limited application	MIT policy affirr state and federal in the US which secure trade and professional secr
Oxford	Research Services Office & Isis Innovation	Some overlap between RSO & Isis, and confederate nature of Oxford complicates procedures.	Mixed: spin-offs started as early as 1950s, but Isis Innovation only established in the late 1980s.	Oxford claims all IP created by staff and students. Defines copyright very narrowly.	All personnel must sign Form INV/2 *after* creating patentable inventions.	Extensive freedo research & priva policies; includes domaining rights

Notes: Domaining is the practice of giving up copyright and IP rights to the public domain. Copyright is generally understood to be the right to authorship and exchange of knowledge created in the form of books, articles, film, sound recording, digital storage, etc. Intellectual Property usually refers to claims over the income stream generated by an item of copyright. There is wide variation across universities, however, in how the two concepts are understood, and not all interpretations appear in accord with basic statutory provisions. Finally, research disclosure refers to the practice of declaring a research breakthrough or invention to the relevant university authority.

E.1 MIT

Institutional Arrangements

At MIT, ultimate responsibility for the commercialisation of research lies with the Office of the Vice President for Research and Dean for Graduate Education, although this institution appears to function largely as a formal clearing house for decisions made by well-staffed and well-funded agencies at lower levels. Key decisions on commercialisation generally fall to two main agencies under the Office of the Vice President: the Technology Licensing Office, and the Industry Liaison Office. The function of the first of these agencies is to oversee the process of technology transfer from MIT to the private sector - largely via licensing and patent sales.

The purpose of the Industry Liaison Office is to provide the private sector with the most 'cost-effective and productive way to mine the rich resources at MIT.' In addition to these formal institutions there are a cluster of dedicated commercialisation programs which function to build lasting strategic alliances between the MIT centres of research and outside organisations. The Technology and Development Program is an important example of one of these.

Practices and Procedures

Due to the sheer size of the commercialisation task at MIT, functions which are usually included under the one roof at other universities are spatially and administratively divided. There is practical method in this division of labour, however. The Technology Licensing Office is primarily, although not exclusively geared towards getting MIT researchers up to speed on their copyright and patent entitlements as a prelude to research commercialisation. It provides a vast spectrum of services and maintains a small army of lawyers dedicated to the task of ensuring a fair return on MIT research.

The Industry Liaison Office provides a range of services that appear to be the opposite of those offered by Technology Licensing Office. Through the Liaison Office, outside companies can obtain information, step-by-step guidance, and legal advice on the research conducted at MIT, and how best to use it. In addition to these 'in and out doors,' MIT commercialisation also maintains a broad strategic edge through the dedicated programs. Representatives of the various programs negotiate at a high level with companies and institutes (internationally and domestic) to further the University's social as well as commercial objectives.

Experience and Learning

MIT is probably better geared toward research commercialisation than any other university in the US (and for that matter, probably the rest of the world). MIT claims to have pioneered the concept of university-industry liaison in 1948 with the founding of the Industrial Liaison Office. In the '70s and '80s, it was a leader in designing the multi-company research consortium, a collaborative model now widely employed at universities across the US.

In 1988, the founding of MIT's Leaders for Manufacturing Program set the standard for educational partnerships with industry. There are more than 100 other progressive industry programs operating out of MIT. Rarely do such programs maintain a strictly commercial focus for as a world leader in the process of collaborative work, MIT can pick and choose its partners and socio-economic objectives.

The Technology and Development Program, mentioned above, was initiated in 1971 under a grant from the US Agency for International Development. In 1975, TDP narrowed its focus to activities in two specific countries; namely, Egypt and Colombia. Activities in both countries emphasised developing close and fully collaborative relationships with established governments, academic institutions, and local business with a view to assisting national development. It is probably fair to suggest that MIT is one of the few universities in the world that is big enough, rich enough, and experienced enough that it can afford to be generous with technology transfer.

Copyright and Intellectual Property

MIT policy affirms US federal copyright law that states that copyright subsists in 'original works of authorship.' A copyright owner has the exclusive right to reproduce their work, prepare derivative works, distribute by sale or otherwise, and display or perform their work publicly. Regarding intellectual property, MIT claims ownership of all IP developed by faculty, students, staff, visitors, and other participants where such IP has resulted from 'the significant use of funds or facilities administered by MIT.'

Generally speaking, MIT *does not* construe the use of offices, libraries, machine shops and the like as constituting significant use of MIT facilities, nor does it construe the payment of salary from unrestricted accounts as constituting significant use of MIT funds.

Disclosure to the Technology Licensing Office is required of all new inventions and breakthrough research which is the outcome of: (1) 'work for hire' type arrangements, (2) sponsored research agreements with organisations outside MIT, and (3) targeted research funds within MIT. On an individual case basis, personnel may seek to challenge these stipulations by applying for a TLO 'waiver.' Any income generated from inventions and research disclosed to the TLO is split as follows: 15% off the top for the Office, and then one-third each for the MIT central administration, research school or department, and researcher(s).

Appointment and Enrolment Practices

Upon appointment to MIT – whether as a member of staff, a student, or a visitor – all researchers are required to sign a so-called 'Inventions and Proprietary Information Agreement.' This contractual agreement obliges all MIT personnel to: (1) promptly disclose to the Technology Licensing Office any new invention or research breakthrough, (2) promptly complete all documentation required by MIT authorities pertaining to intellectual property developed at the University, (3) prepare and maintain accurate written records of intellectual property developed at the University, and (4) promptly supply any written records as required by various MIT authorities.

These requirements *only* pertain to work for hire arrangements, sponsored research agreements, and any targeted research funded by the University. There is little evidence within the MIT's policies on recruitment and promotion of other strictures that go beyond the Inventions and Proprietary Information Agreement. Having said this, MIT schools and departments have considerable latitude in developing policies and procedures in addition to those administered by the central administration of the University. However, any additional policies and procedures must be complementary to those of the central administration, and authorised by the MIT Office of the Provost.

Other Regulatory Prohibitions and Caveats

There are a number of other regulatory prohibitions and caveats that qualify the points made above. Firstly, MIT policy affirms state and federal laws in the US which secure trade and professional secrets. Researchers who may otherwise be required to disclose inventions may have recourse to the proprietary obligations of trade or professional associations.

Secondly, researchers who decide to forego their copyright and IP privileges have a right of public disclosure. 'Domaining' under MIT regulations will *usually* (not sure of the qualifications here) disavow the researcher of any other contractual obligations otherwise entered-into with the University (NB: but not necessarily outside collaborators or sponsors). Thirdly, while there appear to be no direct strictures on the proprietorial rights of University employees, employee contracts may deliberately specify certain pursuits as beyond the scope of normal work-related activities, and this may include reference to business activities (including consultancies).

And finally, the University *does* claim the right to have equity in all companies established to commercialise those inventions and research breakthroughs on-file at the Technology Licensing Office.

E.2 Oxford

Institutional Arrangements

Institutional arrangements for research commercialisation at Oxford are somewhat opaque because of the loose confederate nature of the University. Oxford colleges and halls are largely self-governing corporations with their own constitutions, property, and sources of income. The central administration acts largely as a coordinating organisation performing a small number of 'public good' type functions.

These arrangements notwithstanding, most commercialisation work generally falls to two central agencies responsible to Oxford University Council. The first of these is the Research Services Office, which is 'responsible for the negotiation and administration of all research grants and contracts held by the University' and functions as 'the University's central administrative structure for all research-related matters.' The other agency is Isis Innovation, a wholly owned subsidiary of the University of Oxford, which aims 'to promote the commercialisation of research ideas generated by Oxford academics and owned by the University.' There is some overlap between these two agencies, but the former has institutional seniority by virtue of its IP screening role (RSO approves assignment of

intellectual property to Isis). Day-by-day responsibilities for commercialisation, however, falls to Isis.

Practices and Procedures

Isis Innovation pursues the commercialisation task via two main strategies. On the one hand, it seeks to patent University inventions and find suitable private sector licensees. Isis helps researchers with advice on patenting and exploitation, and provides funding to cover patent applications and legal costs. Licensees are sought using alumni contacts, the 'Oxford Innovation Society,' Oxford Research Online (a web-based catalogue of University research), press releases, and regular contributions to conferences.

On the other hand, Isis also seeks to exploit the intellectual property of the University by establishing start-up companies using University development capital or drawing on external venture capital funds. This incubator role involves a range of services, including the provision of financial and managerial expertise, office facilities, and the development of business strategies. Isis is currently managing about 100 patents and patent applications and has signed over 25 license or option deals since 1997. The agency files around one new patent application each week, and currently has four new start-up companies operating under its purview.

Experience and Learning

We could probably classify Oxford as middle-ranking player in the commercialisation stakes. The University has a strong record of establishing spin-off companies going back as far as the 1950s. Many of these firms, including *Oxford Instruments* and *Research Machines*, are recognised internationally as standard-setters in their respective industries. Historically the emphasis was on providing quality services and products to the wholesale market (particularly government, including health and education). Having said this, much of the commercialisation activity in the period prior to the late 1980s was ad hoc and unplanned – it was welcomed, but by no means the product of strategic design.

Since the late '80s, however, the University has taken a more activist role in the commercialisation process. Starting with the establishment of Isis Innovation in 1987, the University began to see Oxford research as a profitable commodity, and over the following years gradually put in place the necessary legal provisions (the tightening of copyright, IP, and income disbursement policy date back to the early 1990s). Today, there are still the signs of a project incomplete: the overlap between Isis and the Research Services Office appears unnecessary and anachronistic, the University disclosure rules are currently under review, extramural research funding is channelled through at least three offices of the University.

Copyright and Intellectual Property:

Copyright and IP issues at Oxford are currently subject to internal review and definitive comments are therefore difficult to make. Generally speaking, however, the University defines copyright very narrowly to include authorship claims over

'literary and dramatic works, artistic and musical works, audio and video, recordings, broadcasts and cable transmissions.' Intellectual property, on the other hand, is defined very broadly to include 'the legal ownership of ideas and information….embodied in the following forms: patents, copyright, database rights, design rights, trade marks, and any confidential research information.'

Oxford claims ownership of all intellectual property devised, made, or created by staff in the course of their employment at the University, by persons engaged by the University under contracts for services, and by all students. Where any of the above persons creates intellectual property that is capable of commercial exploitation, he or she must report its existence to the Oxford Research Services Office. In the event that the invention or research breakthrough is then handed on to Isis Innovation and commercialised, revenue is split on the following sliding scale:

Total net revenue	Researcher	University	Department	Isis
Up to 50K	63%	7%	0%	30%
50K-500K	31.5%	21%	17.5%	30%
Over 500K	15.75%	28%	26.6%	30%

Under certain circumstances, however, the RSO may opt to commercialise the IP by itself, or hand it over to a third party, in which case a different scale applies.

Appointment and Enrolment Practices:

As an *ex ante* condition of taking-up a position at Oxford (staff, student, or visitor), there are no obligatory contracts which must be signed with direct ramifications for commercialisation. An odd *ex-post* contractual arrangement does exist however. In the event that researchers create intellectual property which is capable of commercial exploitation they are obliged to approach Isis Innovation and fill-out a Disclosure and Assignment of New Technology Form (Form INV/2).

This form is a combination of the disclosure agreements often used at universities in the US (ie. as a precondition of appointment, researchers enter into a formal contractual relationship with the University obliging then to declare new inventions and breakthrough research), and a regular invention description form. This peculiar procedural hurdle might be an ad hoc attempt to square Oxford's extensive freedom of research policies (which have a long history) with the need for a written declaration contract. Aside from this issue, all employees of Oxford are informed upon taking-up their positions that they are obligated to abide by University policy. Presumably this also includes the provisions for IP and disclosure described above.

Other Regulatory Prohibitions and Caveats:

A few other regulations also have bearing on commercialisation at Oxford. First, there is a caveat in Isis' rules that states that a researcher who wishes to exploit their intellectual property by means other than through Isis may do so, subject to receiving permission from the Research Services Office. Approval is granted only if the alternative means of exploitation results in a reasonable return to the University from royalties or equity.

Second, in the event of a disagreement concerning the ownership of an item of intellectual property, which cannot be resolved between the researcher and the University, the matter is referred to an independent expert agreed upon by both parties. The University usually pays for this referral up-front, but can extract a higher proportion of any subsequent revenue stream to reimburse its outlay.

Third, University staff are not allowed to take a proprietorial interest in any spin-off company that arises from their invention or research breakthrough. Further, they are not permitted to have more than 50% equity in any such firm. On both counts the University claims exclusive rights. Finally, subject to the approval of their head of department, academic staff may hold consultancies.

E.3 Stanford

Institutional Arrangements

Commercialisation of the research task at Stanford occurs under the auspices of the Office of the Vice-Provost and Dean of Research and Graduate Policy – an office three layers down from the President of the University. Within the Office of the Vice-Provost are three agencies of importance to the commercialisation process: the Office for Sponsored Research, the Office of Technology Licensing, and the Internal Audit Department. The Office for Sponsored Research assists faculty and students to locate research funding from the public and private sectors.

The Office of Technology Licensing is responsible for 'managing the intellectual property assets of Stanford University' and technology transfer from the University to private industry. Finally, the Internal Audit Department is responsible for financial and managerial oversight across the University, taking a special interest in matters involving contractual obligations between the University and outside collaborators. Although there is some overlap among these three organizations, the Office of Technology Licensing is obviously the first port of call for most commercialisation efforts.

Practices and Procedures

Representatives of the Office of Technology Licensing argue that the commercialisation strategy adopted by their agency is unique in the US. There are two facets to this strategy. On the one hand, the Office contracts-out all the routine and/or procedural functions associated with technology licensing and patent applications.

While the contractors conduct their work on campus within the Office of the Vice-Provost, the functions they perform are done on a fee-for-service and case-by-case basis by external lawyers and administrators. On the other hand, the Office of Technology Licensing concentrates its effort on marketing Stanford research, liaison with potential and established clients, evaluating collaborative projects upon completion, assessment of new technologies and inventions, and negotiating the best deal for University researchers.

The Office takes a 'cradle to grave' approach in its management of licensing deals or collaborative projects and has in excess of 1000 'active' cases on its books at any point in time. The Office of Technology Licensing is very hands-on in the conduct of commercialisation.

Experience and Learning

The most notable thing about the Stanford case is just how rational and progressive it is. Unlike other Universities which have readily identifiable 'loose ends' in their institutional arrangements (the result of evolution rather than design) the Stanford agencies (in particular the Office of Technology Licensing) have well-defined objectives and clearly defined areas of responsibility.

This is the result of Stanford's history of commercialisation. The Office of Technology Licensing was established in the early 1970s on the basis of efforts by one visionary, Professor J Reimers. Reimers, an engineer, conducted independent research in the late 1960s into the kind of technology transfer agency that would be best for Stanford. After reviewing the commercialisation strategies of a number of other US universities, he submitted plans to Stanford management for the establishment of a 'smart' technology transfer program which emphasised organisational performance over administrative logistics.

The new Office was staffed with people with project, management and technical expertise, rather than legal or administrative skills – these functions were to be farmed-out to contractors. After it's establishment in the early 1970s, the Office was well-placed to cash-in on the emergence of Silicon Valley in the mid to late 1970s, and biotechnology in the 1980s. Broadly speaking, the entrepreneurial disposition of the agencies responsible for commercialisation at Stanford makes them well suited to their target environment.

Copyright and Intellectual Property

It is Stanford's policy that all rights in copyright remain with the creator unless the research is a work-for-hire, is supported by a direct allocation of funds through the University for the pursuit of a specific project, is commissioned by the University, makes significant use of University resources or personnel, or is otherwise subject to contractual obligations.

Interpretation of the latter exceptions is the exclusive right of the Office of the Vice-Provost and Dean of Research and Graduate Policy. As a general principal, Stanford claims all rights, title, and interest in intellectual property which is produced by academic staff and students at the University, subject to qualifications based on collaborative research efforts.

All University personnel are under a 'timely disclosure obligation' which requires them to inform the Office of Technology Licensing of any new invention or research breakthrough which might be patentable. The OTL will then proceed to assess the item for patent worthiness, and seek a suitable transfer partner in the private sector if appropriate. Any income stream generated by a successful transfer will be divided as follows: 15% off the top for the Office of Technology Licensing, and of the remaining funds, one third each for the researcher, his/her Department, and the research school.

Appointment and Enrolment Practices

As a precursor of taking-up employment at Stanford, enrolling in a research degree (or coursework degree with a research component) or taking-up a post-Doc, all personnel are required to sign SU-18, the 'Patent and Copyright Agreement for Personnel at Stanford.' This document obliges all staff and students at the University to: (1) disclose to Stanford in a timely fashion – usually 12 months, although a reasonable man test applies – all potentially patentable inventions and research, and (2) recognize and abide by all official University policies regarding inventions, patents, licensing, and copyright. Again, in the event of contestation over clauses of SU-18, the right of interpretation rests with the Office of the Vice Provost.

Work contracts at Stanford can place other strictures on the end-use of research making it a condition of staff remuneration and compensation. There is some flexibility, apparently, in the contracts which may be offered by various research schools at the University. The University pension plan, life insurance, and dependent's tuition reimbursement package may also contain provisions (including cross-referencing to relevant University policies) which potentially bind ex-staff on what they can do once they leave Stanford. Presumably this could include strictures on the use of research performed while still at the University.

Other Regulatory Prohibitions and Caveats

Staff and students at Stanford are not subject to the provisions of SU-18 and associated University policies if they choose to exercise a basic right of open public disclosure. This is a free-speech caveat in the University's regulations which means that personnel can publish or present their findings at a conference with the express intent of giving up their copyright and IP privileges to the public domain. I suspect that this can only be done *before* a disclosure form is submitted to the Office of Technology Licensing, although the 'Invention and Technology Disclosure Form' does not seem to have an express reference to this issue.

There is no reference to attentive constraints on University personnel taking-up the directorship of a firm. There may, however, be provisions within individual work contracts which do indeed restrict the proprietorial rights of University employees. Finally, while there does not seem to be an attentive prohibition on the right of University staff to hold equity in a spin-off company, the University claims an exclusive right to hold equity in any such endeavour.

E.4 UCLA

Institutional Arrangements

Research commercialisation at UCLA broadly falls under the purview of the Office of Research Administration which is directly responsible to the President of the University (equivalent to, say, an academic registrar's division in an Australian University). Beneath the Office of Research Administration are two offices with linked functions; they are the Office of Contract and Grant Administration and the Office of Technology Transfer. The former is responsible for all matters germane to the income and expenditure of research funds at UCLA. It keeps a general record of all funds raised and spent at the University, and a record of the different types of funding (private sponsorship, Federal block funding, specific purpose grants, etc.)

The Office of Technology Transfer is responsible for 'assisting members of the faculty and staff in patenting and licensing inventions and in working with industry in support of the University's education, research, and public service mission.' It is the UCLA's gatekeeper for University-corporate collaboration and the real focus of research commercialisation.

Practices and Procedures

The Office of Technology Transfer has a dual-pronged strategy for achieving its primary organizational task. On the one hand, it targets Faculty members with a multifaceted toolkit offering suggestions on: how to acquire industry involvement and funding for research projects, how to apply for patents and copyrights, and how to broadly manage the commercialisation process. Advice ranges from hands-on practical stuff to more technical and legal concerns.

On the other hand, the Office of Technology Transfer seeks to reach out to the private sector with: information on the UCLA's research strengths, advice on how to find and communicate with relevant University staff and students, and advice on how to manage a variety of industry-University interactions (from complex joint projects to simple purchases of technology). Office consultants are on-hand to deal with any major query. While the Office for Technology Transfer certainly seems to have the potential to preside over big TT projects, it does not seem to be designed for, say, establishing a start-up company or performing incubator-type operations. The emphasis is on facilitation not spoon-feeding.

Experience and Learning

While patent and licensing procedures at UCLA have a long history dating back to the early 1940s, the current Office of Technology Transfer is the outcome of a UCLA administrative report handed down in 1994. Based on a variety of experience with industry liaison, the report recommended that technology transfer activities be researcher/faculty/laboratory centred, and that central University administration only maintain control of policy development, legal oversight, and advisory functions. It was felt that this would facilitate a more flexible and appropriate response to TT projects, and free-up the Office to concentrate on strategic issues.

Indicative of the high level of routinisation of the commercialisation process at UCLA, there are standardised avenues and procedures for handling industry funding. As noted above, the Office of Contract and Grant Administration is solely responsible for *all* research funding at the University. Private funding is included alongside government revenue in a manner that suggests the practice is typical and unproblematic. Finally, and perhaps most importantly, commercialisation is accepted as an important part of the research endeavour at UCLA. The Office for Technology Transfer is headed-up by senior academic and administrative staff with a view to getting results.

Copyright and Intellectual Property

UCLA copyright policy claims to affirm US federal copyright law (ie. that copyright subsists in original works of authorship and that a copyright owner has the right to reproduce their work, prepare derivative works, distribute, display or perform their work publicly). Having said this, the University then proceeds to qualify the legal principle. In addition to exceptions for sponsored, commissioned, and contracted works, UCLA states that '…the University shall own all copyrights to works made by University employees in the course and scope of their employment and shall own all copyrights to works made with the use of University resources.'

Overall, the situation is somewhat messy. Regarding intellectual property, the University claims exclusive rights, title and interest in those inventions and research breakthroughs which *might be readily patentable* (ie. not all research outputs). UCLA researchers who suspect their invention or research breakthrough might qualify for a patent are obliged to disclose the item to the Office of Technology Transfer within a reasonable period. If, thereafter, the item is successfully commercialised and generates an income stream, income is divided as follows: 35% to the researcher(s), 15% to the researcher's department/centre/faculty, and the rest to the University.

Appointment and Enrolment Practices

Prior to taking up employment at UCLA, all staff are required to sign a so-called 'Patent Acknowledgment Form.' This form obliges the signatory to: (1) acknowledge potential University title over inventions and research breakthroughs that are made in the course of employment at UCLA, or while using UCLA research facilities, and (2) 'to promptly report and fully disclose the conception

and/or reduction to practice of potentially patentable inventions to the Office of Technology Transfer.' Employees' salaries and conditions are linked to fulfilments of these obligations, and non-fulfilment could lead to a loss of privileges and renegotiation of employment contracts.

Interestingly, students and post-Docs are not subject to the same strictures as their income is not considered to be compensation for works performed. Scholarships and bursaries are considered to be 'gifts' or 'grants' for the purposes of attaining a degree or qualification, and student researchers are not obliged to fulfill any contractual obligations to the University or anyone else. All staff appointment and promotion must go through the UCLA Human Resources Division (a sub-division of the University Vice-President's Office). This agency appears to have stronger influence over faculty than many other central HR offices at American universities. There is no indication that the Division's policies and procedures go beyond the Patent Acknowledgment Form.

Other Regulatory Prohibitions and Caveats

A number of supplementary regulations complicate the picture painted above. First, the UCLA's privacy policy may actually override the University's disclosure requirements on inventions and breakthrough research. UCLA privacy policies affirm the right not to divulge information of a 'personal and historical nature. Second, UCLA policy asserts that 'Faculty may render professional or scholarly services for compensation and may engage in the practice of their professions to maintain professional competency if such service does not interfere with University commitments and if it gives experience and knowledge of value to his or her teaching or research.' Third, as a general principle, where 'extramural' (outside) funds contribute to the development of a new invention or research breakthrough, *the University still claims exclusive rights, title, and interest* if patents are taken out. There is no mention of a 'domaining right' for UCLA researchers, and no mention of a University right to equity in spin-off companies.

Appendix F: List of Interviewees

Interviews with the following informants capable of providing an informed view of the state of, and structural constraints on, the commercialisation of university research in Australia:

Professor Paul Alewood, IMB, University of Queensland
Professor Warwick Anderson, former Chair, Research Committee, NH&MRC
Dr Peter Andrews, Director, Centre for Drug Design and Development and Institute for Molecular Bioscience, University of Queensland
Professor Jim Angus, Department of Pharmacology, School of Medicine, University of Melbourne
Dr Claire Baxter, Manager, Business Liaison Office, University of Sydney
Dr John Bell, former CEO, Anutech
Ms Anne-Marie Birkhill, General Manager – Operations, Uniquest Pty Ltd
Professor John P Coghlan, College of Health Sciences, University of Sydney
Dr Bill Cowden, CEO, Praxis
Mr Andrew Davies, Uniquest Pty Ltd
Dr Roger Drinkwater, General Manager, Zenome Ltd
Ms Ros Engeldow, Director Research Policy, AVCC
Dr David Evans, CEO, Uniquest
Professor John Furness, Department of Anatomy & Cell Biology, University of Melbourne
Professor Ashley Goldsworthy, CEO, BHERT
Professor Paul Greenfield, DVC, University of Queensland
Dr Kate Grenot, MD BCP Investment Pty Ltd
Professor Stephen Harrap, Department of Physiology, University of Melbourne
Mr David Henderson, General Manager – Technology Commercialisation, Uniquest Pty Ltd
Dr Carrie Hillyard, MD, Bionetworks Pty Ltd and Director, Cooks, Myer & Co
Mr Alan Jones, ISR
Ms Ene Juurma, Executive Manager, Australian Business Health Services
Mr Robert Klupacs, CEO Monash Institute for Reproduction and Development (ex AMRAD)
Professor Richard Larkers, Dean, Faculty of Medicine, University of Melbourne
Professor Frank Larkins, DVC (Research), University of Melbourne
Professor Stephen Leeder, Dean, Faculty of Medicine, University of Sydney
Dr Ian Mair, CEO, CRC for Advanced Composite Structures
Professor Jane Marceau, PVC (Research), UWS
Professor Colin Masters, Department of Pathology, University of Melbourne
Professor Jim McCluskey, Department of Microbiology & Immunology, University of Melbourne
Philip Mendes, Adviser on Technology Law to Uniquest Pty Ltd
Dr Graham Mitchell, Foursight Associates (formerly Eliza Hall and CSL)
Professor Paul Rossiter, PVC (Research) Curtin University
Professor Vicki Sara, Chair, ARC

Mr Don Scott Kemmis, Biotechnology Australia, ISR
Professor Merilyn Sleigh, Dean, Faculty of Life Sciences, UNSW
Ms Gillian Turner, CEO, Unisearch, UNSW
Dr John Turner, CEO, Flinders Technologies, Flinders University
Professor Dick Wettenhall, University of Melbourne
Ms Claire White, Counsellor, ARC
Mr Peter Wills, CRI and Chair, Wills Committee

Appendix G: Interview Proforma

Removing Barriers to Research Commercialisation in the Health and Medical Areas

University-based case studies

5/6/00

Professor Ron Johnston
Executive Director
Australian Centre for Innovation
Faculty of Engineering, University of Sydney,
NSW 2006

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Overall Aims of the Study

- To assist the Wills Review Implementation Committee to develop policy recommendations regarding research commercialisation in Universities by identifying any remaining barriers to research commercialisation
- To provide Universities with better information on domestic and overseas best practice in handling arrangements for research commercialisation

Scope of the Study

The study covers all research fields that have the potential to be commercialised in the health and medical areas.

Nature of the Overall Study

The overall study involves:

- consultations with senior University staff over strategies and problems;
- the collation and analysis of information on different Universities policies and procedures for handling research commercialisation (both in Australia and overseas);
- documenting cases of good (and bad) practice within Australia;
- soliciting submissions from researchers on preferred commercialisation avenues and on the relative strength of different impediments to research commercialisation - an on-line process has been set-up to do this, see http://www.policyintelligence.com/willsimplem.html

The Australian Case Studies

The purpose of the Australian case studies to provide information on the strengths and weaknesses of current arrangements for handling research commercialisation within Australia.

Interview Notes

General

Institutional issues

- *policies and perspectives* towards the role of research commercialisation in the University's mission;
- *rules and regulations* relevant to research commercialisation;
- the *specific strategies* developed to implement these policies;
- the *organisational structures and resources* utilised;
- the *outcomes* achieved to date
- remaining *challenges* and *solutions* being developed.

Good examples

Not so good examples

***Analytical issues*:**

- the range and significance of the different *commercialisation avenues* used (including the impact of any impediments on the preferred commercialisation avenues);
- the *range of technologies* being commercialised and the relationship with preferred commercialisation avenues;
- *cumulative institutional experience* - the extent of 'learning-by-doing' in research commercialisation and its impact upon the current probabilities of success in commercialisation;
- the impact of *country-specific factors* (eg. risk aversion in the finance sector, low levels of business R&D expenditure/technology capability)

Appendix H: Bibliography

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