Best Practice Processes for University Research Commercialisation

Final report

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Executive summary

The challenge

In the context of the global knowledge economy, the traditional role of the university as a generator, repository and disseminator of knowledge and learning is being reworked, at least in terms of new mechanisms to pursue the age-old objectives. There is a growing view that universities have a larger responsibility, and a special capability, to assist in transforming their knowledge into potential fruits—economic and employment growth.

Commercialisation of research, whether in the form of the establishment of new companies to capture maximum benefits, licensing to existing companies offers considerable promise. But it should be recognised that this is but a small component of the ways in which universities can contribute to economic and social advance. Enhanced learning for a larger and wider proportion of the community, not just in formal education but for life, the sheer pursuit of learning, and the continuing contribution to comprehension of challenges and the facilitation of informed debate, deliver much greater returns.

However, with regard to research commercialisation, current metrics suggest Australian universities are well behind emerging performance targets, whether measured in terms of patenting, start-up formation, or revenue from commercialisation. At the same time, these indicators are highly lagged. Other evidence clearly shows that there has been a substantial enhancement in commercialisation performance in many Australian universities in the past five years.

Some myths of commercialisation

Myth No. 1 Universities are a vast untapped source of intellectual property.

Universities do contain a great deal of knowledge and scholarly individuals. But intellectual property is a rare asset, shaped by knowledge, the market and the rules of economics. Moreover, the process of transforming knowledge into intellectual property and then to a good or service is highly complex. Indeed, in many cases the process of research commercialisation is as creative and as complex as research itself.

Myth No. 2 Every time we license or sell a technology we are selling the farm.

In a globally competitive world we must expect to sell a great proportion of the products of our efforts to markets overseas. This also has the benefit of linking us with global markets and operators, providing the basis of future economic activities. The challenge is to ensure we get a good price for our intellectual goods.

Myth No. 3 Australian universities are way behind their overseas counterparts in commercialising research.

The data available demonstrate that the best-performing Australian universities are achieving research commercialisation outcomes broadly comparable with the best in the US and Europe, and way above their average. However there is considerable variability in performance, with a considerable gap to small and regional universities on the whole.

Myth No. 4 Researchers despise the very concept of business and wealth generation.

The great majority of academics with a substantial research performance (on average about half) have a very strong interest in seeing the potential outcomes of their research being realised. This realisation may take the form of a new course, a book, a performance, a new scientific theory, or a technology, such as the computer or the Internet, which will change the world. Some can generate direct commercial returns, while from others the economic return is indirect, and the social return considerable.

Major findings

1. Australian universities have significantly strengthened their research commercialisation capabilities and performance in the past five years. The research-intensive universities (predominantly the Go8) display a level of performance well above the average of American universities, and approaching that of the highest performers in America and Europe. However there is great variability in performance.

2. For the US, one spinoff company is generated from a research expenditure of A$130–177 million, with best performers at A$40 million; in Australia the figures are A$113 million per spin-off for the research-intensive universities, and A$303 for the medium and small research profile universities.

3. Scale is crucial; effective research commercialisation depends first on a sufficient portfolio of research, based on both quantity and quality of researchers; second, it requires sufficient breadth and depth of capacity in the research commercialisation function. This presents a significant challenge to smaller and regional universities.

4. Even in the best-case research commercialisation can only generate 3–5% of a university's revenue. Hence neither governments nor universities should pursue research commercialisation solely or primarily as a major source of revenue. However the direct and indirect benefits to the university and the economy can be considerable.

5. Licensing of protected IP to existing companies is the most common form of research commercialisation and generates by far the most revenue. Success depends crucially on a strong absorptive capacity in industry. Australian industry, with its fragmentation, small size and low R&D investment in general has a relatively poor capacity to absorb university-generated technology. For this reason, many linkages have to be established with overseas firms.

6. The establishment of spinoff firms is an important commercialisation mechanism to hold and develop IP in the absence of suitable receptors or where a high return can be anticipated from future sale. They are most common in the biosciences and IT fields. Despite public perception, spinoffs that generate a huge growth in value, such as Genentech, are rare, unplannable, and usually about 20 years in gestation.

7. The most common financial needs for universities in research commercialisation are for pre-seed capital to fund proof-of-concept and prototype development, and for funds to support adequate IP protection. Given the extreme pressures on the block grant, the only sources of this finance are the new pre-seed funds, angel investors, and in a few cases, returns from previous investments.

8. Effective commercialisation requires non-disclosure. Effective research requires sharing of knowledge. Maintaining an appropriate balance is crucial for the success of both.

9. IP identification is most effectively carried out through decentralised processes close to the researcher, but with effective partnership with the research commercialisation office. Researchers hence need to be assisted to develop these skills.

10. Assessment and exploitation of IP is most effectively conducted by a centralised commercialisation office with a concentration of relevant expertise; performance of research commercialisation offices improves with scale, breadth of expertise and experience.

11. The development of linkages with industry is best performed by the researcher, though the commercialisation office can provide support, particularly through the organisation of networking opportunities.

Some emerging issues

- One aspect of universities that may be particularly challenged by their involvement in research commercialisation is their governance. Their Acts, State Government auditing requirements, and the structure, authority, membership and practices of governing bodies may each raise, and in some cases have raised, evident inefficiencies, tensions and conflicts.

  There is a need to review the elements of governance of universities to ensure they provide an appropriate framework to allow for, encourage and manage research commercialisation.

- The *Bayh-Dole* Act in the US has been called the Magna Carta of research commercialisation. Australia does not face the situation of the US in 1980. IP rights are held by researchers or their institutions. Hence there is no apparent need for legislation. However, the kick-start effect of a major government intervention does warrant appropriate action.

  The National Principles for Intellectual Property, appropriately strengthened, applied and monitored, together with encouragement to universities to establish broad targets, could provide the basis for significantly raising the profile and awareness of research commercialisation.

- The capture of ownership and exploitation of intellectual property, has become of paramount importance in global competitiveness, and hence an increasingly important issue at the national level. The recent announcement by the US National Institutes of Health that it would claim IP ownership in proportion to its share of funding in projects conducted outside the US threatened the IP value and ownership of all such projects.

  Vigilance, representation and appropriate policy may be necessary to protect the ownership of IP generated in Australia.

- While IP identification is best conducted by researchers, it is not a function to leave to the researcher alone. The UniQuest model of placing a 'commercialisation manager' in each faculty represents best practice, as they can play the roles of 'idea finder' and 'idea developer'.

  The key challenge of raising the awareness and IP identification capabilities of research staff requires training and other support programs. KCA and AIC may have a role in developing and promoting such courses.

- There is an emerging tension between the growing requirement for collaboration between researchers and institutions to achieve effective research teams, and the requirement of venture capitalists for 'clean IP', where ownership is clearly determined.

  The National Principles for IP Management should be revised to provide clear guidelines for the negotiation of IP ownership in cases where more than one institution is involved.

- There are few forms of financial support for early-stage research commercialisation activities. The ARC specifically excludes support for attendance at international conferences, where contacts with industry partners might be established. The NHMRC has established a modest competitive industry development grant to support proof-of-concept research.

  Research funding agencies should examine their support for research commercialisation and consider establishing significant competitive schemes to assist with the costs of pursuing research commercialisation.

- Research commercialisation success is largely driven by considerations of scale. While these attributes of scale are fairly readily available to the larger and research-intensive universities, the smaller and regional universities do not have this capacity. This regardless that they well may (and do) possess pockets of research expertise capable of generating valuable IP.

  There would seem to be a need to encourage networking between smaller and regional universities to share their research commercialisation expertise. This might be a role for KCA and/or AIC and for case managers involved with local (eg. BITS funded) incubators.

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1 Objectives

The primary objective of this study has been to inform consideration of performance and appropriate policy with regard to research commercialisation in Australian universities, in particular by the Ministerial Committee oversighting implementation of the "Backing Australia's Ability' (BAA) Program.

It has been conducted in a climate of significant actual or potential changes in the environment in which university research and its commercialisation is conducted eg.:

- the implementation of the first stages of the BAA Program, including the establishment of an independent ARC with substantially increased funding;
- the pronouncement of four priority areas for research funding[1] and the establishment of a consultative process to further the introduction of appropriate priorities[2];
- the initiation of a major review of higher education[3].

The specific requirements of the project were to evaluate and propose models for best practice in university decision-making processes underpinning research commercialisation, addressing:

- identification, assessment, protection and management of intellectual property with commercial potential;
- identification of sources of potential investment and industry partners, and strategies to develop ongoing dialogue in areas of common research interest;
- criteria and processes to guide and facilitate the selection of appropriate commercialisation strategies and business models;
- support mechanisms such as appropriate incentive structures and opportunities to engage business partners, including through industry placements, to assist researchers to identify market opportunities in formulating research projects to acquire skills and understanding of business processes; and
- collaboration as appropriate with other institutions to share commercialisation expertise and facilities.

[1] See http://www.arc.gov.au

[2] See http://www.dest.gov.au/priorities

[3] See http://www.dest.gov.au/priorities

2 Introduction

The commercialisation of research is generally regarded as being "the process of transforming ideas, knowledge and inventions into greater wealth for individuals, businesses and/or society at large". [4]This includes both economic and social benefits. It has to be understood as one strand of technological innovation, which "involves the successive transformation of knowledge into practical artefacts, tools or practices."[5]

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 fifteen years. Various reports have emphasised a lack of availability of capital, a truncated industry structure, problems of scale, an inappropriate research and university senior management culture, inappropriate university reward systems and other structural obstacles to researchers, and the importance of people over procedures or practices.[6]

This preoccupation can be readily understood given the comparatively high levels of public investment, and low levels of private investment, in R&D in Australia compared with other OECD nations. This has been supported by the widely held view, backed up by numerous anecdotes[7], that Australians perform excellent research, but are poor in translating it into wealth generation for the nation.

Thus:

> *While much of Australia's industry research may be the world's best, it is of limited value unless it successfully enters the commercial market and those commercial opportunities are maximised for the good of industry, institutes and the community at large. It has been a recurrent theme of major reports into Australian research that the commercialisation activities are handled poorly. An entire re-orientation of commercialisation processes and methodologies is demanded*[8]

[4] PMSEIC (2001).

[5] Tornatzky et al, p.7, (1999).

[6] Recent reports include OECD (1997), FASTS (1998), (1999), Matthews and Johnston (1998), Cripps et al (1999), ARC (2000).

[7] For example, the 'black box' flight recorder and flame photometry.

[8] Australian Institute of Commercialisation (2001).

However there is reason for caution in accepting this view unquestioningly. The theme of 'excellent research, poor commercialisation' is repeated, at least in most English-speaking countries around the world. We noted previously that:

> *it is hard to find a United Kingdom science and innovation policy statement under both current and previous government that does not mention these policy objectives* [ie. enhanced linkage].[9]

Even in that citadel acknowledged as the world leader in commercialisation of public sector research:

> *Universities in the United States have been criticized in some circles for being more adept at developing new technologies than moving them into private sector applications.10*

The need for a more adequate empirical base against which to evaluate the performance of research commercialisation by Australian universities is evident.[11]

In an earlier report[12], we noted that research commercialisation, with its emphasis on a direct commercial return to the researcher or research organisation, was but a subset of a much larger issue of capturing economic and social value from the investment in knowledge production and dissemination.

We also found that 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

[9] Matthews and Johnston (1998), p.3.

[10] Siegel et al (2002); this has led some Federal agencies such as NSF to provide incentives for universities to form partnerships with firms through mechanisms such as Science and Technology Centers that require universities to attract matching funds from industry.

[11] This lack should be largely resolved by the shortly to be published survey of Australian university research commercialisation practices and performance by the ARC, based on the US AUTM (Association of University Technology Managers) licensing survey.

[12] Johnston et al (2000).

research capability and a weak industrial capability to translate these options into commercial success. Key elements of this new approach include:

- a 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.[13]

These shifts are reflected in the recent release of a set of national principles for intellectual property (IP) management jointly produced by the ARC, ATICCA (now KCA), the AVCC, DETYA and DISR. It provides a definition of IP, charges research institutions and individuals to consider the most appropriate way of exploiting IP generated from publicly funded research, and presents brief principles addressing:

- institutional policies
- identification of IP
- protection of IP
- ownership of IP
- assessment of existing IP
- management of IP
- sharing of benefits
- transparency and reporting, and
- potential conflict of interest.[14]

Around the world, governments and universities are acknowledging that knowledge has become the central asset in commercial and economic competitiveness. As a consequence there is a considerable premium on the establishment of mechanisms that can most effectively shape knowledge production to align with economic objectives, and can provide the commercial sector with relevant knowledge, where, how and when required.

[13] Johnston et al, R., Matthews, M., and Dodgson, M., Enabling the Virtuous Cycle: Identifying and Removing Barriers to Entrpreneurial Activity by Health and Medical Researchers in the Higher Education Sector, 00/14, Evaluations and Investigations Program, Department of Education, Training and Youth Affairs, 2000.

[14] http://www.arc.gov.au/publications/arc_pubs/01_01.pdf.

The crucial element is widely regarded as linkages between knowledge generators and knowledge users. Thus:

> *The nation that fosters an infrastructure of linkages among and between firms, universities and government gains competitive advantage through quicker information diffusion and product deployment…The performance of an innovation system now depends, more than in the past, on the intensity and effectiveness of the interactions between the main actors involved in the generation and diffusion of knowledge*[15]

It is important to recognise that this emphasis on linkages (commonly referred to as industry-science relationships—ISRs, in Europe) is not just 'business as usual'; ie. that oft-repeated objective of getting a better return on the public funds invested in public sector research through more effective commercialisation of those ideas nationally.

Rather, with knowledge as the key asset in economic competitiveness, a two-way process is required which incorporates mechanisms that can shape knowledge production to align with economic objectives and can provide the commercial sector with exploitable knowledge.

Thus:

> *ISRs are not simply transactions that mirror a clear-cut division of labour in the production of knowledge. They represent an institutionalised form of learning that provides a specific contribution to the stock of economically useful knowledge. They act not only as knowledge transfer mechanisms but also in other capacities eg. building networks of innovative agents,or increasing the scope of multidisciplinary experiments.*[16]

These themes have been echoed in a number of recent Australian reports. Thus the White Paper on Research and Research Training[17] emphasised the distinction between and the mutual importance of discovery and linkage in the knowledge economy. 'Discovery' is essential to produce new and significant knowledge. 'Linkage' is the mechanism whereby that knowledge is shaped by economic and social needs, and whereby the whole body of knowledge can be accessed in support of the pursuit of specific objectives.

The Chief Scientist, in his report, 'Chance to Change'[18], has argued that:

> *We need a SET (science, engineering and technology) capability that is an integral part of the national innovation capability and has the best*

[15] OECD (2000).

[16] OECD, (2000), p.163.

[17] Kemp (1999).

[18] Batterham (2000).

> *chance of supporting economic and social goals in the 21st Century…The objective of new funding should be new business and wealth creation.*
>
> *The innovation system is dependent on strong links between all players, government, industry and research performers…We need to think about new ways to develop alliances, connections and partnerships between the SET base and other players…We need to introduce incentives for researchers in universities and government research agencies to make the most of the knowledge they create, and build upon this to elevate their role in the economy. The challenge for them is to stimulate and facilitate the increased transfer of knowledge to business and society, across all sectors of the economy.*

In a similar fashion, the final report of the Innovation Summit Implementation Group[19] stated:

> *Successful commercialisation depends not only on the individual performance of players, but also on how they interact with each other. Knowledge flow in Australian innovation is vital, including relationships amongst business, government, research agencies, non-government organisations and universities.*

The mechanism that has received the most attention has been the 'spinoff' firm. One justification is that they "provide the clearest path to the greatest industry/economic benefit through new and established industries".[20]

This view is in accord with the OECD perspective:

> *Public officials in universities and Ministries throughout the industrial countries are currently extremely interested in fostering the creation of spin-offs from the public sector research base. The reason is simple. Research-based spin-offs are generally understood to be small, new technology based firms whose intellectual capital originated in universities or other public research organisations. These firms are thought to contribute to innovation, growth, employment and revenues…*
>
> *Spin-offs embody the success of this new business model… a small number have become very high-profile companies…the successes of these stellar firms enhances the reputation of their parent, helping to attract students, faculty and funding…The prospects of winning big make spin-off support an attractive gamble.*[21]

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[19] ISIG (2000), p.xi.

[20] PMSEIC (2001), p.9

[21] OECD (2001), p.7.

This promise has led to a perhaps excessive enthusiasm in some quarters. Thus:

> *The vision to build a compelling future must be underpinned by challenging 'stretch targets' for commercialising public sector research. Australians must be motivated to imagine and work towards a future where our national debt could be eliminated over the next 10 to 15 years by supporting 200–250 more companies of the scale of Cochlear, Resmed, Vision Systems or Radiata.*[22]

However the data suggest a somewhat more sober prospect. Even in the undisputed leader of spin-offs, the US, the top 132 universities only averaged two new firms per year, and 40% produced none. Moreover, apart from the few spectacular exceptions, revenue from spin-offs represents only a very small proportion of both commercial income and R&D investment.

Columbia University is ranked No.1 in the US with its earned revenue approaching US$100 million per year from patents, but it was granted a very below average of 34 patents per year between 1994 and 1998. Yale University concluded from a review of its 850 invention disclosures from 1982 to 1996 that 1% produced 70% of revenue, 4% accounted for 90%, and 88% of disclosures did not cover their management costs.

At the same time, there is an evident growing unease, at least in some quarters, about the capture of public investment for private gain. For example, a recent OECD conference raised a series of questions, including:

- *Does the emphasis on the commercialisation of intellectual property significantly change the mission of universities?*
- *Is the emphasis on commercial exploitation distorting or restricting the public good element of public research?*
- *Is creating more efficient public sector knowledge markets encouraging or limiting the diffusion of public sector research results?* [23]

Other questions have been raised by Auditors-General in at least two States[24], concerned that universities are assuming unacceptable commercial risks and even operating outside their Acts.

Clearly, the time is ripe for a thorough examination of both practice and performance in university research commercialisation in Australia and overseas.

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[22] PMSEIC (2001), p.36; the authors acknowledge this requires a ten-fold increase within five years; elsewhere (Johnston et al, 2000, p.14) we have noted that the first two of these companies required 30 and 20 years, respectively, from research to their current commercial success.

[23] OECD (2000a).

[24] NSW, where the Public Authorities Finance Act (PAFA) requires universities to register all commercial activity, and Victoria, where an inquiry is underway.

3 The enhanced role of linkages in innovation and economic competitiveness

> *The nation that fosters an infrastructure of linkages among and between firms, universities and government gains competitive advantage through quicker information diffusion and product deployment.*[25]

The context has been provided by the emergence of the global knowledge economy, and the emphasis on regional development. In Europe at the national level, in the US largely at the State level, and in Australia at the regional level, economic development has become a significant driver of public support for higher education. Thus:

> *The economic environment is one which will handsomely reward those individuals, companies, countries, and states which are able to pull together creative and skilled people, leading edge science and technology, capital and smart disciplined management to serve far flung markets with new products and processes ... University-industry technology transfer relationships are an important venue for all parties to advance their interests in the context of the technology-based economy.*[26]

3.1 The growth of linkages

The growth in number and variety of linkages is most notable in the US. Thus in the decade to 1996, university industry interactions (measured by the number of scientific papers resulting from university-industry collaboration) has increased by 50% and the scientific input to innovation (measured by the number of citations on US patents to US scientific articles) by 300%. In an AUTM sample of universities, license agreements increased by 70% and royalties by 200% between 1991 and 1996. The number of universities actively engaged in technology transfer increased eight-fold since 1980 and now numbers more than 200.[27]

[25] US Council on Competitiveness, 1998, cited in OECD (2002), p.15

[26] Tornatzky et al (1999).

[27] Thursby and Kemp (2002)

There are similar trends in Australia, though of a lower absolute magnitude.[28] A more detailed examination of data will be provided in Section 5.

What is driving these linkages?

First, it is apparent that in some new industries, growth has accelerated in areas where innovation is directly rooted in science (eg. information technology, biotechnology and new materials). Hence companies recognise that scientific advance is key to a competitive position. What is more, there is a general view that the next generation of emerging technologies (eg. nanotechnology, gene technology, photonics, etc.) will provide the basis for a completely new set of industries.

Second, the advances in information technology and telecommunications, and particularly the capabilities of the Internet (originally developed for use by researchers) have increased enormously the extent and speed of communication and information transfer among researchers, and others with whom they communicate.

Third, the pressures of competition and increased corporate governance have led to an 'unbundling' of corporate activities, a distinction between what is core to the business or an area of strategic advantage, versus other support activities, which may be effectively outsourced. Hence most of the major corporations have decreased their in-house R&D capability and replaced it by a series of deep linkages to key R&D capabilities outside their organisation, mostly in the universities.

Fourth, financial, regulatory and organisational changes have seen the emergence of a framework for the development of a market for knowledge, through the financing and management of a wide range of commercialisation activities. This was initially concentrated in the venture capital industry, but with the recognition that this market could provide the opportunity not only for considerable financial returns, but also a most effective source of intelligence about emerging technologies and knowledge, other financial institutions, consultants and law firms have also entered the field.

Fifth, the increasing pressures on the public sources of finance for universities has provided a strong incentive for them to seek other sources of funding to reduce their dependence on the public purse and political decisions.

Sixth, the demand for responses to emerging social needs, such as the ageing population and environmental sustainability, requires innovations that commonly require multi-disciplinary approaches and the complementary competencies of the public and private sectors.

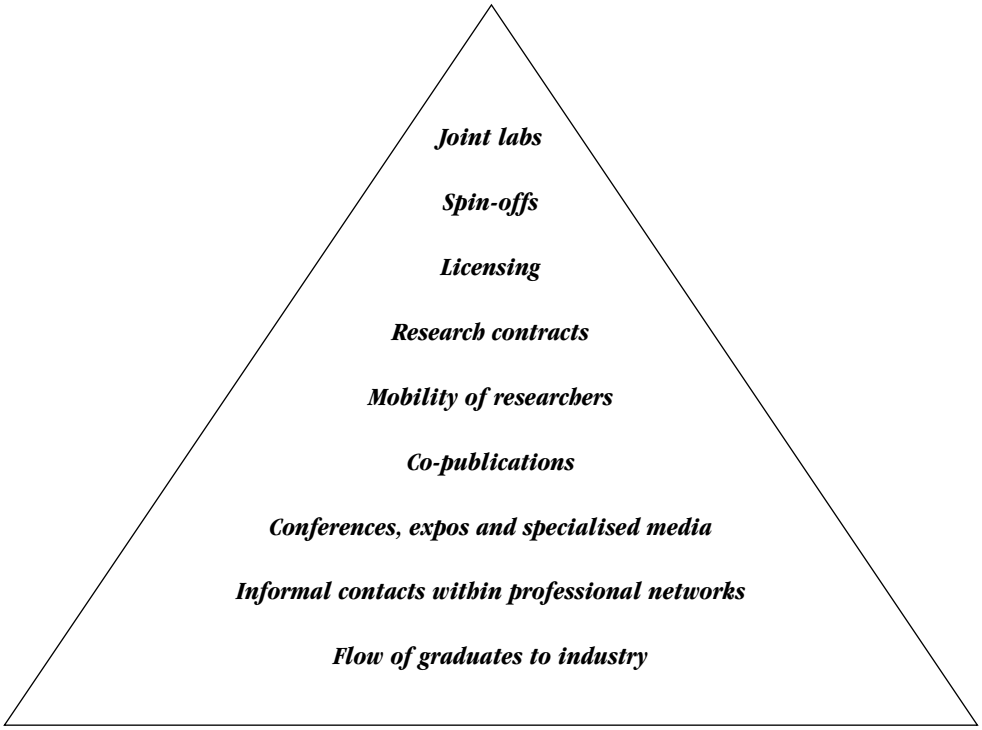
[28] Matthews, M. and Johnston, R. (1999)

Two emphases have tended to dominate consideration of linkages. The first, shaped by the leading edge of competition in the global knowledge economy, focuses on the relations between global companies and world class universities. The emphasis is on leading edge research, rather than a narrow judgment of 'fit'. The second is focussed on the generation of spin-off firms—a phenomenon which represents only a minor component of industry-science relationships, but which may have a larger consequential impact.

3.2 Types of linkages

However, it needs to be remembered that the great majority of linkages are of a service nature, wherein science, usually via the mechanism of universities, provides the knowledge and/or the skills to address specific problems.

A 'pyramid' of mechanisms of linkages has been developed by the OECD[29], shown below:



[29] OECD (2001)

Barre identifies an array of 'channels of industry-science relationships', or linkages, in his study of the French situation.[30] These are:

- Contract research—contracted and collaborative
- Consultancy and services—transfer of expertise, testing, access to specialised equipment
- Intellectual property transactions—licensing, equity investment
- Knowledge spillovers and spin-offs—via science parks, incubators, alliances
- Teaching/training
- Labour mobility—exchange of staff, placement of PhD graduates, joint labs

Another useful concept, drawing on the insights of knowledge management, differentiates between know-how and expertise, characterised by a low level of codification and appropriability, to an exclusive patent, for which both codification and appropriability are necessarily high.[31] The process of research commercialisation, as in the generation of intellectual property, can be usefully considered as the transition from low to high codification and appropriability.

3.3 Intellectual property issues

The OECD has examined the role of national regulations, incentives and practices in the area of intellectual property rights (IPR). The ownership of IPR is viewed as providing a strong incentive for universities to commercialise the research they produce. It is noted that:

> *In nearly all OECD countries there has been a marked trend towards transferring ownership of publicly funded research results from the state (government) to the (public or private) agent performing the research. The underlying rationale for such change is that it increases the social rate of return on public investment in research.*[32]

However, there is considerable variation in who holds the IPR, and trends in different directions. Thus:

- the US Bayh-Dole Act of 1980 provides for performers (normally organisations) of federally funded research to file patents and grant licenses;
- in Canada, about half of the universities grant ownership to individual researchers with the other half retaining title;

[30] Barre, R. (2001)

[31] Ibid, p.23

[32] OECD (2001), p.48

- in Australia, only one university has directly transferred IPRs to individual researchers—viz University of Melbourne;
- however in Germany, a new law will shift title to invention from the professor to the university;
- the Italian government implemented legislation in 2001 granting IP ownership to researchers at universities;
- in the UK there are various sets of rules; eg. while most Research Councils grant IPRs to institutes, the Medical Research Council retains IP ownership;
- in Japan, title to an invention is determined by a committee, which decided in favour of individual researchers in 78% of cases in 1998.

Is granting ownership to the researcher a good formula? In theory, it should increase researchers' interest in commercialisation. However, putting all the responsibility for disclosing and protecting ownership on a single individual is considered to reduce the likelihood of patenting and subsequent licensing.[33] To address this, Cambridge University set up a company with Nuffield funding to which researchers could go to get help with patent and other costs of commercialisation in exchange for a share of the IP ownership. In Sweden this role is played by regional development agencies. Such parallel access to support is essential.

The reasons given are the burden of action, particularly if it cuts down available time for research, the growing costs of litigation, a reluctance of firms to enter into licensing agreements with individuals. In addition, an individual may choose to commercialise abroad, leading to a reduction in national benefits. Hence, good practice favours IPR being held by institutions, but with individuals obtaining a share of resulting royalties.

There are generally no standard national, let alone internationally comparable, formulae for allocating royalties from patents and licenses. In Australia, practice varies considerably between the various universities. Formulae vary from the relatively common 3-way equal split between the inventor, department and the University, to more complex schemes involving 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.[34]

There is a common concern to build the infrastructure and skills base to support effective IP management across many OECD nations. This concern is a direct reflection of the increasing interest and urgency in achieving competitive advantage in the global knowledge economy. Thus, in many countries, though commercialisation offices have existed in universities for a number of years, their focus has been on administering the IP related to contract research with firms rather than to assisting researchers to disclose, patent and commercially exploit their inventions. As one example, the UK

[33] Ibid, p.52.

[34] Johnston et al (2000)

government has announced a commitment of £10 million to strengthen the capacity for commercialising IP in public scientific research establishments.

However, the OECD also emphasises that the recent surge in interest in and pursuit of patenting needs to be kept in perspective:

- Revenues from patenting do not significantly reduce the need for other sources of funding (gross revenues from licences represent on average less than 3% of R&D funding of US universities).
- Patenting is not a reliable indicator of scientific output (patenting is highly skewed to biomedical sciences).
- The main contribution to innovation of increased patenting is not to make public sector research more commercially relevant but to improve information on the existence and location of commercially relevant research units.
- Buoyant patenting activities should not overshadow the parallel development of other forms of linkage; eg. CRCs.
- Greater autonomy of publicly funded research organisations increases their contributions to innovation through patenting and other means when it is paralleled by greater accountability.[35]

At the institutional level, an interesting example of promotion of research commercialisation is provided by the case of the Flemish Inter-University Institute for Biotechnology (VIB). It was established in 1995 by the regional government of Flanders and combines nine university departments and five associated laboratories with over 700 researchers. It has three major objectives: performing quality research, fostering technology transfer through licensing and spin-offs and enhancing the public image of biotechnology.

Its approach to evaluation of technology transfer and commercialisation involves preparation of a 'record of inventions':[36]

> *Research groups must disclose each invention or potential invention to the technology transfer group of VIB. Comparable universities are chosen as benchmarks. VIB sees this as a very important evaluation criterion for its research departments. In addition, VIB takes into account the number of research collaborations and licence agreements of each research department, although this is of lesser importance than the record of inventions.*

The aim is for the research departments to excel in research and the generation of potential IP, leaving the institution to commercialise the IP effectively.

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[35] Ibid, paraphrased from p.24.

[36] OECD, 2001, p.56.

4 Conceptual developments in university research commercialisation

One concept to have demonstrated significant value in both analytical and policy terms is the *innovation progression gap*. If the commercialisation process is viewed as essentially a linear path:

idea development> opportunity recognition> concept formulation> concept development> product launch> market penetration

The major gap in financial support occurs between opportunity recognition and concept development, which is identified with pre-seed funds. The lack of adequate funding of this kind, and of understanding by policy-makers of the characteristics of this special kind of financial investment, appear to constitute a major barrier in the commercialisation of university research.[37] The other serious gap in smaller institutions is the competence to make effective assessments of disclosures. The cost of such support activities in Australia usually has to come out of university block grant teaching and research funds.

Another approach from the perspective of knowledge management offers considerable insights. The emphasis of science policy has been on research ie. the generation of new knowledge, and its subsequent transfer and commercialisation. However, within the concept of the knowledge cycle, other crucial components include knowledge identification, knowledge evaluation, knowledge capture, knowledge exploitation, knowledge storage and knowledge diffusion.[38]

Within this model, while research commercialisation remains important, effective development of knowledge-based economic activity depends on performance along all elements of the cycle.

This concept can be further developed through the idea of *'knowledge supply chains'*.[39] There has been a great deal of management research directed towards supply chain management designed to improve the effectiveness of linkages between suppliers, manufacturers, distributors and retailers. This is

[37] Johnston, Matthews and Dodgson (2000)

[38] Johmston and Blumentritt (1999)

[39] developed by John H. Howard of Howard Partners

now being applied to knowledge supply. The principles of supply chain management applied to knowledge involve[40]:

- The knowledge process is treated as an integrated system where all tiers of potential knowledge partners are identified and included in the process.
- All participants know what particular need knowledge is trying to satisfy, what specifications and form define the knowledge transfer, who the ultimate customer is and when they need to use that knowledge.
- There is an open flow of communication and information among all partners so that each has all the information and specifications needed to maximise the value added to the process.
- There is quick feedback between each knowledge supplier and user on the efficiency and effectiveness of the knowledge exchange.
- Partners in the process feel that their involvement benefits both the total system as well as themselves/their organisation.

  The principles apply to:

  – existing codified knowledge located in an established knowledge base—library, web site, database;
  – new skills, learning and developed through formal education and training;
  – embedded knowledge and skills through the addition of new people;
  – new knowledge acquired and generated through sharing of best practices or consulting with relevant experts; and
  – new knowledge generated by a formal R&D process.

Just as the material supply chain concept has stressed the value of working with all tiers of suppliers, industry needs to work effectively with all tiers of the academic system. To sustain the benefits of knowledge transfer it is vital that the two institutions recognise the value of their knowledge process and interdependencies if the barriers to historical separation and organisational culture are to be overcome.

Recognition by industry and academia that they are part of an integrated knowledge supply chain gives a sense of mutual purpose. It also identifies and defines relative strengths and gaps in the system. The supply chain concept also plays down the distinctions between basic (discovery) and applied research. In a contemporary context businesses and universities

[40] (NGM) Next Generation Manufacturing Project, Knowledge Supply Chains (Bethlehem, PA: Agility Forum, Leaders for Manufacturing and Technologies Enabling Agile Manufacturing, 1997).

interact as much in the areas of basic research, (particularly in the area of science based innovations) as they do in contract research and product development.

> *The knowledge supply chain concept is particularly appropriate for considering the flow of information about the outcomes of research between universities and industry. It also points to other dimensions and aspects of the relationship. This is indicated below:*

It has been argued that today's disconnected knowledge system parallels the non-integrated material supply chains of 10 years ago. The fact that supply chain management has been able to remove the distrust and communication barriers that existed between customers and vendors gives hope and direction for achieving similar results in the knowledge process.

A knowledge supply chain relies on communication. This is socially, not technologically driven. It involves tangible (material) knowledge and increasingly intangible (immaterial) knowledge. Moreover, the emphasis is on the sharing, rather than the transfer, of knowledge. Public research organisations have an important role to play in assisting in the development of knowledge chains.

In a series of papers Etkowitz and colleagues have developed the concept of the *triple helix of university-government-industry relations*.[41] They argue that it is no longer the case of considering university-industry linkages to achieve commercial outcomes, and university-government relations addressing investment in research and education. Rather, the three are not only converging but are now in continuing dynamic interaction, reshaping each other.

The same argument has been developed in different directions to identify the emergence of a new model of the university—from the research university to the *entrepreneurial university*[42]:

> *The entrepreneurial university is a result of the working out of an 'inner logic' of academic development that previously expanded the academic enterprise from a focus on teaching to research. The internal organisation of the Research University consists of a series of research groups that have firm-like qualities…sharing qualities with a start-up firm even before it directly engages in entrepreneurial activities.*[43]

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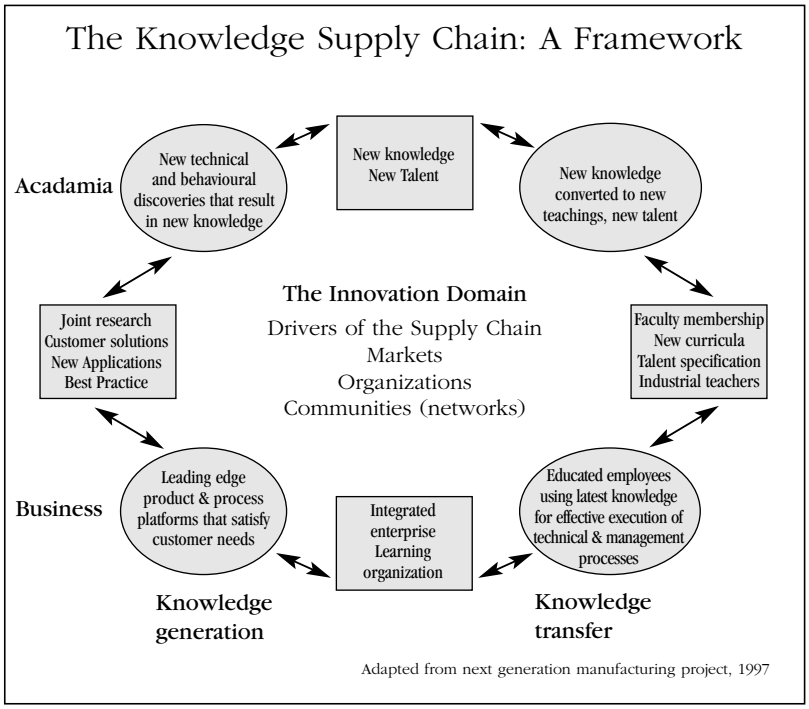
[41] Etkowitz and Leydesdorff (1997)

[42] Clark (1998)

[43] Etzkowitz (2002)

An alternative view characterises the evolution as one *from sponsorship to partnership in university-industry relations*.[44] The evolution is characterised through four stages: the science-society contract as captured by Vannevar Bush, the era of strategic research, the Science Park, and the knowledge partnership. This model, which corresponds substantially to the much—discussed Mode 2 model of science,[45] emphasises the joint creation of knowledge between researcher and user, as opposed to the transfer of knowledge from researcher to user.



The importance of the issue of university-industry linkages has generated a substantial literature. Some 150 papers have been identified and reviewed focussing on five issues of cooperative agreements between universities and firms: typologies, dimensions, motives and benefits, barriers and obstacles and success.[46]

[44] Jacob et al (2000)

[45] For example Johnston (1998)

[46] Valentin (2002)

5 Financing commercialisation

Recent thinking about entrepreneurs and start-up ventures has drawn a distinction between two categories:

- the 'promising' start-up that follows an evolutionary growth path, and
- the 'venture backed' start-up that follows a very rapid growth trajectory.

5.1 Promising start-ups

Contrary to popular belief and perceptions, most noteworthy businesses have quite unremarkable beginnings. Most of the Inc 500 companies bootstrapped their ventures with modest funds provided from credit cards, mortgages and other loans. The median amount was $10,000. Only five per cent of companies raised funds from professional venture capitalists[47].

The reality is that in the US only five per cent of the *Inc* 500 companies start with venture capital funding and overall, venture capitalists fund only a few hundred businesses a year. That is, of the 500,000 new firms that are founded in the US each year:

- the vast majority are small, low growth, such as laundromats and restaurants;
- roughly 50,000 (10%) receive funding by private equity investors, or angels; and
- only about 500 (0.1%) receive "seed stage" venture capital financing.[48]

Globally less than 20,000 companies received venture capital in 2000. On the basis of research on entrepreneurship in Australia, we suggest that the ratio for Australia is similar.[49]

Recent research has indicated that the following characteristics are associated with "promising start-ups"[50]:

[47] Bhide, (2000) p.15.

[48] US Advanced Technology Program, (2001), p.24.

[49] See for example Hindle and Rushworth (2001)

[50] Bhide, 2000, p.17–19

Initial conditions (endowments)	Start by copying or slightly modifying someone else's idea Lack of industry or managerial experience
	Lack of proprietary ideas and verifiable human capital precludes most entrepreneurs from raising much outside funding
	Funding is through 'bootstrapping' with modest personal funds
Nature of business	Low investment—cannot make up front investments required to undertake projects that have promise of large total returns
	High uncertainty—actually helps entrepreneurs with limited endowments; if they don't succeed, they don't lose too much—ie. low profit and low cost of failure
Opportunistic Adaptation	With limited funds, little reason to devote much time to planning and research—modest profit doesn't merit much and high uncertainty limits its value
	Sketchy planning and high uncertainty requires adaptation to many problems—like jumping from rock to rock up stream rather than building the Golden Gate from a blueprint
	Responses derive from spur of the moment consideration designed to maximise cash flow—rapid fire pinball rather than a strategic game of chess
Securing resources	Difficulty in convincing customers, employees, credit and other resource providers to take a chance; no track record and without a capital base cannot underwrite others' risks
	Cannot offer credible money back guarantees, employment contracts or collateral
	Undertake an extensive search for parties whose interests, values, and decision-making processes allow them to take a chance on a start-up
	Offer special deals to their first resource providers to compensate for risk as a "guinea pig". Frame trade offs through face-to-face selling, persuasively, by accentuating the positives and down playing the negatives
Traits and skills	High tolerance for ambiguity
	Entrepreneurs have to confront fluid, rapidly changing situations where they cannot anticipate outcomes, let alone probability distributions
	A high tolerance for financial loss does not influence the propensity to start ventures where entrepreneurs do not invest much capital or face high opportunity costs for their time.
	Entrepreneurs can influence their luck: in businesses that lack differentiating technologies or concepts, personal traits such as open mindedness, willingness to make decisions quickly, ability to cope with setbacks, skills in selling help identify the winners.

5.2 Venture capital backed start-ups

To finance the growth of the business an entrepreneur may seek *venture capital*. In this context, venture capital covers *any* resource available and applied to support the creation and growth of a business venture. In contemporary discussions of entrepreneurship however, venture capital is often more narrowly defined as funding provided by professional venture capital investors.

The 'professional' or formal venture capital sector consists of specialist venture capital firms that raise funds for investment and perform the functions of assessing applicants, monitoring the investee businesses, assisting management and, ultimately, liquidating those investments to obtain a return to those who provided funds.

Venture capital also covers:

- Corporate venture capital, which includes funds established by corporations to invest in new and growing businesses. These companies include Microsoft, Intel, 3i, Cisco, Dell, Oracle, Sun, and Nokia[51].
- Angel or seed financing—provision of equity by high wealth individuals acting alone or in groups. This sector is very significant for financing new and growing companies.

Venture capital came into prominence as an asset class as a vehicle to commercialise 'knowledge capital'. More traditional asset classes (debt, securities, etc) are generally available to companies to finance investments in more tangible assets such as physical capital and land. Venture capital investors typically invest in higher risk private companies, with the expectation of higher than average returns.

5.3 Characteristics of venture-backed start-ups

Professional venture capitalists provide capital to an elite group of entrepreneurs after careful due diligence and research. These venture-backed start-ups have a number of characteristics:

- the venture capitalist provides counsel and connections in addition to funds;
- there is a high level of quality and depth in the founding team;

[51] Ten of the world's 22 largest venture capital fund investors were corporations. The value of venture investments made by the US corporate sector amounted to 17 per cent ($8 billion) of all US venture capital. See Schuyt (2001)

- there is a unique technology or concept; and
- there is a verifiable record of business achievement in previous endeavours.

Venture capital investors are after big winners. They seek propriety products, experienced managers capable of managing rapidly growing firms, minimum investment thresholds and require extensive due diligence. From this perspective there are few individuals that start with the ideas and human capital necessary to secure venture capital funding.

The prototypical start-up that flourishes in the venture capital setting has a technological solution to a mass problem or opportunity. It produces something that has a high selling price, high margins and an expectation of being profitable in two to three years.[52]

5.4 The venture capital investment "model"

One of the most important contributions of the venture capital asset class is the venture capital investment model. This model has a number of distinct features:

- discontinuity—an investment time frame of three to five years;
- portfolio investment—a number of investments to balance gains and losses;
- minority stake—capacity to exercise control, but not ownership;
- sharing/spreading risk—investment with other parties;
- fast value creation (capital gains) rather than income growth (dividends);
- staged investment—on the basis of milestones being achieved; and
- exit strategy—knowing how to "get out" of the investment.

The last five years has seen the application of the venture model as a basis for investment decisions by a broad range of investors. Investors using the venture model include corporations (as an alternative to the traditional capital investment decision process)[53], high wealth individuals ('angels') acting individually or in syndicates and superannuation funds. These investors do not seek the rates of return characteristic of the formal venture capital sector.

Venture investments also tend to be made after a personal and trust based relationship has been established. The importance of establishing high levels

[52] Norton (2001)

[53] Foster and Kaplan (2001); many companies manage new investments through a separate venture fund—but the model can be applied without a separate funding pool.

of trust between the users and providers of funds under the venture model cannot be over emphasised.

Typically, investors in venture capital seek returns of between 25 and 35 per cent per year over the life of an investment. This high level of return is sought to balance the high risk involved in this investment class. As venture capitalists invest on a portfolio basis, and as there will be some inevitable failures within the portfolio, the target returns sought from individual investments will be very high—sometimes as much as 10 or twenty times an initial equity investment.

As a consequence, venture capitalists:

- seek investments that can be exited relatively quickly – mergers and acquisitions and management buyouts can deliver good returns over a short time frame;
- require an established, experienced and credible professional management team that can get a company up and running quickly;
- look for potentially very high performing start-up companies which require a stream of cash inflow rather than large up front payments (such as for the purchase of major infrastructure items for research and development);
- invest over a relatively short time; and
- seek to avoid companies that are not growing.

5.5 Reality checks

Venture capital backed start-up companies have had a significant increase in shaping popular beliefs, and the direction of formal research, about new business ventures. These firms have made significantly greater contributions to certain high technology fields such as semi-conductors and genetic engineering and are geographically concentrated – notably in California and Massachusetts.

> *Approximately one third of the world's venture capital goes to nurturing innovation in Silicon Valley: most of the money is raised there, more entrepreneurs have moved there and most of the wealth created stays there*[54].

The US National Commission on Entrepreneurship has commented that

> *Of all the myths and misunderstandings surrounding entrepreneurship, the role of venture capital is perhaps the most*

[54] *Economist* February 20,1999

> *exaggerated. The venture capital phenomenon has received so much attention that it often appears to those looking in from outside that most decent business ideas would receive venture backing. The media lavishes coverage on venture backed start-ups, and has highlighted the massive growth in business "incubators" around the country.*[55]

The aggressive profiling of professional venture capital has created a number of problems:

- an unrealistic expectation in the entrepreneurial economy about access to this sort of finance;
- a skewing in public policy towards support for venture backed start-ups; and
- a lack of focus on support for business development in addressing market risk for established technology based companies.

[55] US National Commission on Entrepreneurship, (2001), p.17

6 Evidence of university research commercialisation performance

6.1 Approaches to metrics

Responding to the growing recognition of the economic importance of research commercialisation, significant efforts are underway to develop a reliable approach to benchmarking industry-science relationships, led principally by the OECD and the EC[56]. Early results have demonstrated the difficulty of developing robust indicators, and of the high level of structural variation between countries. As in every benchmarking process, there is a grave danger of simplistic (or politically driven) comparisons of like with unlike.

However, as has occurred previously in the development of international standards for the reporting of R&D activity, initial progress towards consensus is being made. Based on the sorts of typologies of ISRs outlined in Section 2, ten categories of interaction have been developed together with appropriate input and output indicators:

- contract and collaborative research
- faculty consulting with industry
- cooperation in innovation projects
- science as an information source for industrial innovation
- mobility of researchers
- training and education
- patent applications
- royalty incomes
- spin-offs
- informal contacts, networks.[57]

[56] For a recent review of the state-of-the-art, see OECD (2002).

[57] Developed by the Austrian Federal Ministry of Economy and Labour in 2001; it includes a presentation of best available data for eight European countries, USA and Japan; presented in OECD (2002), p.40.

In practice, the most interest has been focussed on items 7, 8 and 9 —patents, royalties and spin-offs.

The AUTM survey identifies seven key ordinal metrics:

- number of new products
- number of start-ups
- location of start-ups
- number of licences and options
- value of license income
- economic impact, in terms of contribution to GDP and employment
- tax revenues arising from sales of products.

The challenge of weighting them for scale in order to achieve comparability remains. The most commonly used divisor is total research revenue.

Against these categories, they claim that in 1999 the commercialisation of university research resulted in more than US$40 billion in economic activity, including $5 billion in tax revenues, and 270,000 jobs.[58]

A particular difficulty in developing reliable data has arisen over the definition and categorisation of spin-offs. Commonly the term is used loosely to refer to any new, small, technology—or knowledge-intensive firm whose IP has origins in a public research institution. However a more careful analysis has identified three different types of spinoff:

- consultancy and R&D contracting firms *that exploit competence shortages and bottlenecks in their economic, industrial and R&D environments: they sell highly specific expertise in short supply outside academia [which] frequently occur when radically new technologies emerge;*
- product orientated firms *that are organised around a well-developed product concept and focus on the advanced development, production and marketing of that product;* and
- technology asset oriented firms *that are concerned with the development of technologies which are subsequently commercialised through spinning out new firms, licensing, joint ventures or other types of alliance.*[59]

It is worth noting that a survey of Swedish spin-offs identified 80% as operating in the first mode, 25% in the second, and only a handful in the third (some operating in more than one mode). The identification of university spin-offs with high-growth technology-based firms evidently captures only a part of the entrepreneurial action.

[58] reported in Allan (2001)

[59] Stankiewicz (1994)

Indeed it is argued that[60]:

> *The majority of firms set up by researchers have no need of venture capital, licensing agreements or management teams with financial experience. These are needed for one specific type of spin-off: firms that are going tobe quoted on the NASDAQ or new stock markets. These constitute the1–2% "gazelles" of spin-off firms.*

An alternative taxonomy reported by Thorburn[61] distinguishes between four categories:

- direct research spinoffs—companies created to commercialise IP arising out of a research institution where the IP is licensed to the new firm;
- technology transfer companies—set up to exploit the research institution's tacit knowledge and know-how;
- indirect spinoff companies—companies set up by present or former staff and/or students drawing on their experience, but with no formal IP licensing arrangement with the institution;
- spin-outs to already existing companies.

In order to test the definition used in different countries, the OECD surveyed its members to determine which of five possible categories were included. These were:

i any new firm which includes a public sector or university employee as one of the founders;

ii any new firm which licences technology from a university or public research institute;

iii any new firm which includes a student or alumni as one of the founders;

iv any new firm that started in an incubator or technology park affiliated with the public sector or a university;

v any new firm in which a university or national laboratory has made an equity investment.[62]

The responses were highly varied. Official definitions in the US include all five categories, though the AUTM survey is restricted to the second category, but includes research hospitals as well as universities. Australia includes categories i, ii and iv, the UK only v, and Japan reported no definition. Germany applies categories i, iii and v, but includes firms founded by recent graduates, public employees and employees from medium and large firms with an advanced

[60] Mustar (2001)

[61] Thorburn (1999)

[62] Callan (2001)

degree. Hence the need for absolute caution in comparing data from different countries.

Nevertheless a general picture of research commercialisation has emerged. There is widespread agreement that the level of research commercialisation by universities has increased significantly over the past 5–10 years, with a notable recent acceleration.[63] Moreover universities are regarding research commercialisation, for various reasons, as a strategic objective.

While a great deal of attention has been directed to spin-offs, at least partly driven by a small number of spectacular successes, the major return to universities remains through licensing to well-established firms. Even these returns, if they are to be significant, rely on "a blockbuster every ten years —licensing is a big-hit game".

A picture of a typical spinoff has been constructed. They:

> *appear to be small technology oriented firms with relatively slow growth rates but long lives. They are preponderantly found in the life sciences and in the ICT fields. Their early stage funding comes from multiple sources, and public funds are relatively generous… Spin-offs do seem to maintain ties with their 'parent institution', thus confirming the suspicion that they are an important 'mediator' or 'translator' spanning academia and industry.*[64]

This historical position is challenged by Bray and Lee[65], who calculate based on AUTM data, that the financial return from a spin-off is ten times the average annual income from a license. If the exceptional million-dollar equity sales are excluded, the average value of equity is still comparable to what can be issued as a license fee.

A maturing understanding suggests the question of license or spinoff is not (or is no longer) a sensible one. It is only rarely an either/or situation ie. for any technology there is a choice of licensing it to an existing company or a spinoff.

One development favouring the spinoff is the growing propensity of multinational firms to outsource their new business and product generation, via the mechanisms of acquisition and mergers—territory more familiar to business.

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[63] Confirmed through impirical analysis of US university performance by Thursby and Kemp (2002)

[64] Callan (2001), p.51.

[65] Bray and Lee (2000)

A second factor, highly significant in the Australian context, is the availability of appropriate existing potential licensees. For example, the University of British Columbia (see Section 6.2) discovered when it started marketing UBC technologies in 1990, that one of the most frequent obstacles was the lack of suitable licensees in the province. Hence the strategic decision was made to focus on spinoffs to maximise regional economic and social benefits. Hence context can shape commercialisation strategy.

The data which should provide the first comprehensive picture of university research commercialisation activities have been collected by the ARC, following and assisted by the AUTM approach. Definitive benchmarking must await the release of these highly anticipated results.

Recognising these various cautions and caveats, there is nevertheless value in reporting the comparative empirical results that have been collected.

6.2 Empirical data

United States

Through the AUTM annual survey the US (and Canada) has the most comprehensive and reliable data collection on university research commercialisation activities. Highlights of the AUTM survey for 1998 are:

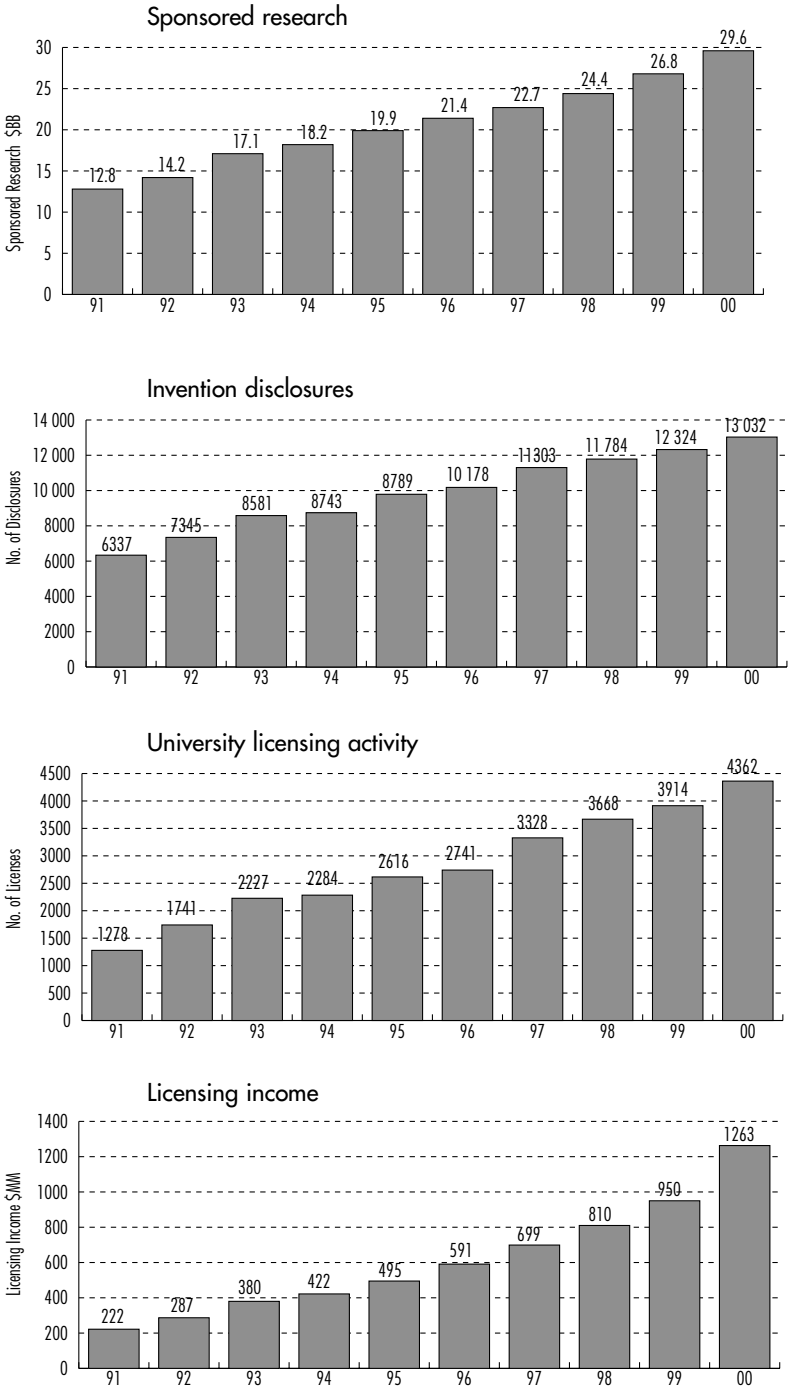
- 385 new products;
- 364 new companies based on an academic discovery, up 9% on the previous year (80% located in the state of the university that licensed the technology);
- average start-ups of 2.1 per institution, though 35% reported no start-ups;
- average R&D expenditure per start-up US$68 million, 41% of which was government funding;
- 3668 new licences, up 10% on the previous year;
- start-ups accounted for only 10% of total licenses;
- start-ups generated only 6% of total gross license income.[66]

More recent data, extending the time base for comparison, has been obtained from the AUTM 2000 survey.[67] These show that sponsored research has more than doubled over the past decade, as has the number of invention disclosures.

[66] Compiled from Massing (2001) and Yencken and Gillin (2002)

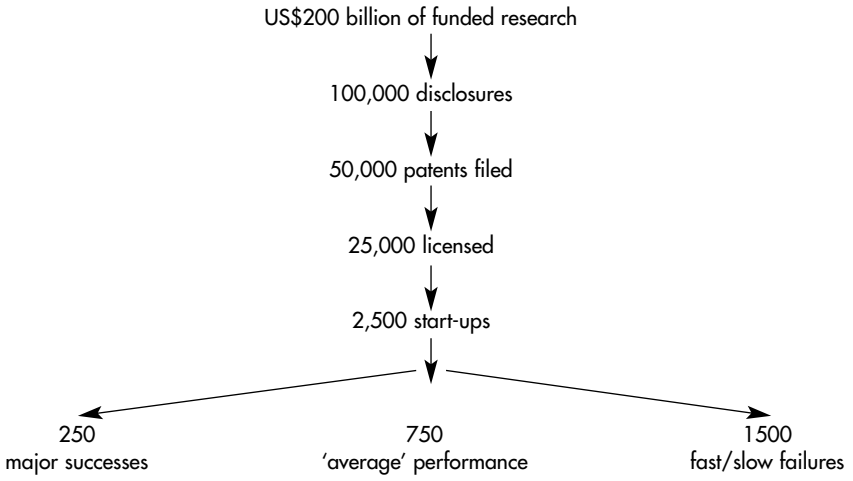
[67] These data were kindly supplied by Dr Louis Berneman, Managing Director, Center for Technology Transfer, University of Pennsylvania and ex-President, AUTM

Figure 6.1 AUTM FY2000 licensing survey



Licensing activity, as measured by the number of licenses has grown by 340%, and licensing income by 570% in the same period.

On the basis of ten years experience in the US, Berneman has developed a 'cascading tiers of performance':



The top performing universities are widely differing, from public to private, large to small. The following Table lists the top ten institutions in 2000 by absolute license income, and reports also license income as a proportion of R&D expenditure and ranking by number of patents.

Major US university research commercialisation performance

University	License Income US$M	Rank	License Income as % of R&D	Earning Licenses	Number Patents
Columbia	89	1	32	212	60
California	74	2	4	715	460
Florida State	57	3	43	14	14
Yale41	4	13	28	33	
Washington	28	5	6	185	64
Stanford	28	6	7	339	111
Michigan State	24	7	11	48	42
Florida	22	8	8	45	68
Wisconsin	18	9	4	191	65
MIT16	10	2	346	121	

It is apparent that performance is not a statistical matter ie. reflects the level of activity. Rather the majority of large licence income is derived from one or two exceptional licenses.

Canada

Yencken and Gillin report:

- 231 licenses by Canadian universities in 1998 (average 5.1 per institution) of which 66 (28%) were start-ups—average 1.5 per institution (significantly higher than the US 12%);
- The University of British Columbia reports 7–8 spinoffs at an average of US$20–25 million. (see Section 6)

United Kingdom

Similarly, for the UK:

- 199 spinoffs created in 1999/2000 compared with 338 in the previous five years;
- proportion of research income from business 12.3% up 13%;
- total patents filed up by 22% to 1534;
- Herriot-Watt University reported an average of 5 spinoff companies per year, producing one per £14 million;
- Strathclyde University reported a similar number at £10 million R&D expenditure per spinoff.

More recent data have been collected in an AUTM-type survey of British university performance in research commercialisation in 2001 by Nottingham University Business School in an ESRC-funded project.[68] These show first of all a very high level of variation between the British universities; as a result reports of mean results have limited value. Recognising this limitation, key results are:

- a mean of 7 licenses or options, a mode of 5, 42% reporting zero;
- a mean of 1 license generating between £50–249k, but with 53% reporting zero;
- a mean of £44k income per license, with 38% reporting zero; this compares with the US AUTM figure of £96K—220% higher;
- a substantial variation in the ratio of invention disclosures per research income, ranging from 1:£180k to 1:£50m, with an approximate relationship

[68] Preliminary results kindly provided by John Yencken; presented by M. Wright, A. Lockett and A. Vohora, Glasgow, 21 May 2001

declining with scale; ie 20 disclosures for £20 million, 25 for £40 million and 40 for £60 million; these ratios are well below those found in the US;

- a mean of 11 patent applications, and 3 patents granted, but with 39% reporting zero;
- a mean of nine spinoffs in the past five years, but with 41% reporting zero; of these a mean of only two had venture capital finance;
- no clear relationship between spinoff formation and research income, varying from one per £3.3 million to one per £80 million.

Together, these figures show UK universities performing at a substantially lower level of research commercialisation when compared with the US.

Australia

In advance of the release of the ARC AUTM survey results, Yencken and Gillin's survey of 29 of the 37 Australian universities provides the most comprehensive data:

- 38 start-ups in 2000 from universities and CRCs, (averaging 1.3 per responding institution), up 40% from 27 the previous year;
- a total of 52 direct spinoffs (+18 from CRCs) and 16 technology transfer company formation (+3 from CRCs) in the period 1998–2000;
- of the direct spinoffs, 87% were trading at the end of 2001; they were concentrated in the medical (36%) and IT (24%) fields;
- significant differences of performance by State: NSW provided 40% of spinoffs, Queensland 22%, ACT and Victoria 10% each, WA 9% and SA 7%;
- senior management was in agreement about the importance of research commercialisation, but the more research intensive universities were far more positive about choosing a spinoff over a licensing route to commercialisation and the adequacy of resources to support a stable of spinoff companies; most larger universities expected to generate earnings from spinoffs in the range of 6–25% of total commercialisation earnings, whereas the smaller universities expected to generate only 1–5% of income from this source;
- R&D expenditure per spinoff, averaged over 1998–2000 was A$113 million for high research profile institutions, A$303 for small-medium institutions and A$15 million for CRCs;

- the spinoff generation rate from Australia's best performing universities—$54.8 million per spinoff at the University of Queensland and $58.1 million at the University of Sydney, are only slightly higher than the leading overseas universities' performance of around A$40 million per spinoff.[69]

Comparative data

Another interesting comparative survey has been made of the member universities of the Association of Pacific Rim Universities (APRU)[70]. Ten respondents were from the North America, nine from Asia and one each from Australia, New Zealand and South America. Most data are reported as a comparison between the North American (NA) and other universities:

- research expenditure as a proportion of the operating budget remained constant at 22% in NA over 1998–2000, but increased from 16% to 20% in the others;
- industry research funding has remained constant at 13–14% in NA, but increased from 14% to 19% in others;
- NA universities reported an average of 126, 133 and 137 disclosures for the 3 years; for the other universities it was 46, 70 and 86; however the growth rate of the latter is 29% compared with 4% for NA;
- patent applications in both US and home country by NA universities is about four times greater than that for other universities eg. in 2000, NA universities had a mean of 109 patent applications and 37 issued, compared with 29 and 11 for others (in their home country);
- NA executed a mean of 46 licenses in 2000 compared with 34 for others,; however the latter's growth rate over the 3 years is 21% versus 9% for NA;
- the mean number of licenses to existing companies (NA 36, other 11 for 2000) far exceeded the number to start-ups (NA 7, other 4);
- NA universities had a mean of 136 licenses yielding income compared with 9 for others;
- the mean size of research commercialisation offices was 14 staff in NA and 4 in others; and
- the NA universities report results on average about double those resulting from the AUTM survey—they are obviously high performers in research commercialisation even in the US context.

[69] Drawn from Yencken and Gillin (2002)

[70] 22 of 34 members responded; details at http://www.apru.org

6.3 The performance of research commercialisation organisations

> *The basic message for both university technology transfer managers and companies seeking technology partnerships is fairly straightforward: the world is complex. There are no single or simple approaches to university-industry technology transfer. Each approach is context-specific, and will be more or less a fit with the perspectives and aspirations that stakeholders bring to the process… It is incumbent upon universities and their industrial partners to choose those linkages and approaches that aremost suitable for their environment.*[71]

There has been sufficient experience of research commercialisation in the US and Europe to draw some generalisations on the operations of organisations established to manage and conduct this function.

A study of the relative productivity of university technology transfer offices (TTO), based on the AUTM benchmarking surveys for the years 1991–1996[72], found that their activity, as measured by licensing, is characterised by constant returns to scale (ie bigger is better). Environmental factors such as State-level economic growth, and institutional factors such as the presence of a medical school or the public status of the university are subsidiary variables of significance.

Productivity may also depend on organisational practices, three of which, based on qualitative data, are identified as significant. The first is faculty reward systems:

> *It appears that the propensity of faculty members to disclose inventions, and thus increase the 'supply' of technologies available for commercialisation, will be related to promotion and tenure policies and the university's royalty and equity distribution formula.*[73]

The second factor is TTO staffing and compensation practices. In particular, a skill mix which emphasises entrepreneurial and business, as opposed to legal skills, appears more conducive to new business formation.

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[71] Tornatzky et al, p.24 (1999).

[72] Siegel et al (2002)

[73] Ibid, p.19

The third factor is cultural barriers between universities and firms. The researchers suggest that 'boundary spaning' between researchers and business may be a crucial skill.

Another review of best practices in US university technology licensing offices conducted for the Japanese External Trade Organisation[74] has developed a five-point strategy for effective operation:

- capitalise on potential success quickly by establishing specific strategies to seek new inventions early, examine a large number of potential disclosures rapidly, review and document probability of finding licensees through proven assessment techniques, select the strongest candidates and devote time to them;
- broaden the resource base available to staff by maintaining awareness of external organisations and their capabilities;
- manage expectations of all stakeholders by establishing effective tools and communication systems;
- increase familiarity with business incubation issues; and
- capitalise on networking opportunities, training programs and other membership benefits.

Everett Rogers[75], using AUTM and NSF data, has measured the technology transfer effectiveness, defined as the degree to which research-based information is moved successfully from one individual or organisation to another, for 131 US research universities. The single strongest correlation was with the date of establishing the Office. Beyond this, universities that are relatively more effective are characterised by higher average faculty salaries, a larger number of staff for technology licensing, a higher value of private gifts, grants and contracts, and more R&D funding from both government and industry.

The finding about the importance of the number of TTO staff is supported by the view of the Managing Director of Edinburgh Research and Innovation Ltd (see Section 7), that a minimum threshold of 4–5 staff is necessary for effective operation.

[74] Allan, p.6 (2001)

[75] Rogers et al (2000)

7 Case studies

7.1 Georgia Institute of Technology, US[76]

Georgia Institute of Technology ('Georgia Tech) was established in 1885, and with a research expenditure of US$264 million ranked 30th among all US universities and 18th among public universities in 1999. Industry sponsored research amounted to $63 million, 24% of total research expenditures, placing Georgia Tech second among the top 100 universities.

It has a highly active technology transfer program, generating $2 million in license income in 1999, a royalty return on investment of 0.8%. License income ranks in the 68th percentile, royalty return in the 53rd percentile, new licenses to start-ups in the 89th percentile, and total start-ups (10 in 1998–9) in the 94th percentile of the AUTM survey.

The Georgia Tech Research Corporation holds title to all intellectual property developed in the university, encourages faculty participation in start-up firms, and normally takes equity as part consideration for granting a license.

The primary organisational driver is the University's Office of Economic Development and Technology Ventures, which has three major units: the Advanced Technology Development Center—a business incubator for early stage technology-based companies, the Economic Development Institute—Georgia Tech's state-wide business and economic development service organisation, and VentureLab—a new initiative aimed at expanding technology commercialisation from Georgia Tech research.

Since 1980, the home of much of Georgia Tech's entrepreneurial activity has been its technology business incubator. Since it opened it has graduated 81 companies, generating 4600 jobs in the Georgian economy. In 2001, incubator companies attracted in excess of $300 million in investment.

In addition to space, the incubator offers assistance services which enabled it to win the 'National Incubator of the Year' Award in 1996. Prominent among these is a Faculty Research Commercializing Program which researchers with grants from $30–100,000 to develop early stage innovations into workable prototypes or to conduct proof-of-concept research. From 1999, each grant recipient has been matched with a business advisor from the private sector or business school.

[76] Based on Tornatzky et al, 2002, pp. 27–41

The Economic Development Institute has been in operation for 40 years and has 200 employees. Its prime role is to coordinate economic development activities between Georgia Tech and the State of Georgia. One such initiative is the Georgia Research Alliance, founded in 1990, which makes strategic investments in developing centres of research excellence in areas crucial to future economic growth—notably advanced communications, biotechnology and environmental technologies. In its lifetime it has raised $276 million in State funds, directed to establishing senior positions and providing infrastructure.

One outstanding example is 'Yamacraw'—a $100 million five-year State initiative to make Georgia a world leader in the design of broadband infrastructure systems, devices and chips. The initiative is intended to strengthen faculty capacity, attract prominent companies, enhance education, create a seed fund and launch a design centre to commercialise research.

The outreach orientation is also promoted through the $100 million applied research organisation—Georgia Tech Research Institute, which employs 1000 staff in contract research for governments and industry.

VentureLab has been designed as a 'one-stop-shop' resource for faculty members interested in commercialising their technologies who have limited knowledge of the processes involved. There are four service components:

- technology assessment which evaluates commercial potential and determines the most appropriate commercialisation pathway;
- educational outreach explaining principles and practices involved in technology commercialisation, IP protection, licensing and managing and capitalising start-ups;
- a network of VentureLab Fellows composed of experienced entrepreneurs who can provide mentoring; and
- gap funding in the form of PreSeed Awards to support prototype development or proof-of-concept research.

7.2 Ohio State University, US[77]

Founded in 1870, 'Ohio State' is one of the largest public land grant universities, with 55,000 students. What is most interesting is that it "has gone through something of a renaissance … which involved an exciting rethinking of mission, goals and investment…Ohio State is a national benchmark about how creative leadership and planning can turn a large institution toward a new path".[78]

[77] Based on Tornatzky et al, 2002, pp.55–56

[78] Ibid, p.55

In 1999 it reported research expenditure of $333 million, 19th among all US universities and 12th among public universities. Industry sponsored research was $52 million—16% of the total, which placed the university 6th in the country against this criterion. This represented a 271% increase over the 1992 figure.

Ohio State license income was $1.6 million in 1999, for a royalty return on investment of 0.5%. License income ranks in the 64th percentile, royalty return in the 43rd percentile, and new licenses to start-ups in the 52nd percentile of the AUTM survey. Through the initiatives of the Office for Technology Licenses, particularly presentations to Department meetings, invention disclosure rates have been increasing at 20–25% per annum.

Strong targets have been set, via its '2010 objective', to achieve 10 programs in the top 10, and 20 in the top 20. Particular areas of focus are minimally invasive surgery, cardiovascular bioengineering, sensors, computational design of new materials, computer visualisation and wireless technology.

An Office of Technology Partnerships was established in 1999, top unite under one organisational umbrella and location the university's licensing function, collaborative research with industry, entrepreneurial development of university technology and a mandate to encourage state-wide initiatives in technology-based economic development.

In addition to internal changes to permit university employees to take equity and a revised IP policy, there has been a considerable emphasis on external partnerships:

- Scitech, a research park located adjacent to the university but operating through a separate non-profit corporation, which promotes on-campus research alliances between businesses and the university and to provide facilities to house spin-off enterprises;
- a Technology Commercialization Corporation to groom raw technology into business opportunities suitable for seed funding; this involves securing IP rights, researching market opportunity, development to reduce the technology to operational practice and building a new corporate entity; it has established a pre-seed fund of $700,000;
- relationships with the venture capital industry through an 'affinity' Vc investment strategy, which requires independent VCs to make 'best efforts' to commercialise university inventions, in return for a university investment in the range $0.5–2.0 million;
- a State Technology Action Fund designed to support early commercial development, including proof-of-concept and prototyping.

7.3 University of British Columbia, Canada[79]

The University of British Columbia, one of Canada's top research universities, with some 35,000 students and over 1700 faculty, has committed itself strongly to playing a leading role in economic development in the region. Its University-Industry Liaison Office (UILO) is responsible for commercialisation of the university's technology and all industry-related research agreements. Though established in 1984, it is only in the past few years that the benefits of this investment have started to emerge.

The UILO has set an exemplary standard in documenting its processes and performance. The Table below provides the latest summary of achievements. This set of measures could profitably be adopted by all universities in reporting their research and research commercialisation performance.

Summary of Uilo Activities

	1999/2000	2000/2001
Value of research projects	$165.5M	$198.8M
Number of research projects	4,104	4,147
Industry sponsored portion	$39.8 M	$38.8 M
Number of invention disclosures received	127	135
Number of patents filed (all countries)	161	183
Number of patents issued (all countries)	63	62
Number of licence agreements completed	22	28
Number of active licence agreements	156	181
Number of technologies under licence	293	328
Royalty income to UBC	$1.7 M	$5.9 M
Value of equity portfolio (est. as of March 31)	$14.8M	$11.2M
Value of liquidated equity	$2.5M	$2.7M
Number of spin-off companies formed	8	13
Number of spin-off companies formed (since 1984)	91	104

* all financial measures in Canadian dollars

Over the eight years from 1993/4 to 2000/01:

- the number of disclosures has increased from 80 to 130 per year;
- the number of patents filed has fluctuated year by year, but remained at an average of about 150;

[79] Drawn from http://www.uilo.ubc.ca

- similarly, patents issued have varied around a mean of about 50 per year;
- licences have steadily and substantially increased (125%), from 80 in 1993/4 to 180 in 2000/1;
- royalties remained largely constant at about $1million through to 1998/9, but jumped dramatically to $6 million in 2000/1; liquidated equity likewise increased from a negligible figure in the same period to in excess of $2 million;
- spinoff formation has remained relatively constant, at the rate of 8–10 per year, but with obvious growth in cumulative formation, performance and contribution to the economy;
- by March 2001 104 spinoff companies based on university research discoveries had been established; these employed 2500 people, attracted in excess of $550 million in private investment, and reported collective revenues of $155 million;
- in 1997/8, spin-off companies contracted over $3.5 million of research to the university—25% of total industry-supported research; they had also paid a total of $3.7 million in royalties—40% of total royalties received;
- the university held equity in 31 public and private companies with a market value in 1998 of $8 million.

7.4 Edinburgh University, Scotland[80]

In 1999 the University of Edinburgh put in place an integrated research growth and commercialisation strategy, the key elements of which were:

- to increase the volume of research activity whilst retaining its international quality;
- to put in place an effective means of evaluating ideas emerging from the research base and identifying the appropriate exploitation route for them;
- to establish an integrated company development program to facilitate new company generation; and
- to adopt policies and procedures to facilitate exploitation and motivate academic members of staff.

[80] Information provided by John Yencken, including the Edinburgh Research and Innovation Ltd Annual Report 2001

A set of five year objectives were set. With respect to research funding, there were targets of growth by 15% per annum cumulative, 40% from non-public sources and a tripling of industry funded research. Over the four years to 2001, research funding doubled, driven by a 70% increase in the value of industrial research in two years.

The Table below outlines the research commercialisation targets and achievements.

Measure (per year)	Target Year 5 performance	July 2000 performance	July 2001 performance
Disclosures	100	82	76
Patents filed	25	19	10
Licenses signed	15	11	13
Commercial Research £M	15	7.5	12.9
Spinouts*	5	4	
Start-ups#	10–15	11	

* wholly based on university technology, in which the university maintains a financial interest

\# established by students or researchers, without transfer of university IP, but supported in kind for their wider economic benefit

Key commercialisation policies include:

- ownership of all employee IP by the university;
- normally patent to UK preliminary filing; next stage to European filing or PCT only when there is a serious licensing prospect;
- pre-seed funding provided through UK Challenge Grant, up to £250k for proof of concept, with 10% equity for each £50k provided.

Collaborative research, commercialisation, business development, incubation, consultancy and on-line education are managed by Edinburgh Research and Education Ltd. The view is that the technology transfer/research commercialisation function requires a minimum of £300–500k, 4–5 people including business development managers and lawyers.

The performance of the University of Edinburgh against US universities average performance[81] (see Section 6) provides an interesting picture of comparative outcomes:

- disclosures are achieved at almost half the cost to the US universities;
- the R&D revenue base of patents and licences is comparable,;
- the US universities generate almost twice the level of royalties from their R&D investment; however

[81] Data generated by ERI Ltd and provided by John Yencken

- the University of Edinburgh generates four times as many spinoffs as the US universities for the same R&D expenditure; and
- Edinburgh generated nearly twice as many start-ups arising from student/staff entrepreneurial initiatives where no university IP was involved as spinouts where IP transfer was involved.

Research Commercialisation Efficiency 1999–2000

Annual Research Funding ($M) required for	US AUTM university average	University of Edinburgh
1 disclosure	2.3	1.3
1 patent	4.8	5.5
$1M in royalties	34.9	18.1
1 license	7.2	9.5
1 spinoff company	85.7	21.0

Comparative data of this kind should of course be interpreted with great caution. Relative performance can vary significantly from year to year. In addition, as we have already pointed out, there are many different factors operating in the US compared with anywhere else in the world.

One clear conclusion is that universal benchmarks are almost certainly inappropriate. National or regional comparisons are likely to be far more appropriate and useful.

7.5 University of Twente, Netherlands

The University of Twente is an entrepreneurial research university, founded in 1961 to focus on developing and linking the technical and social sciences. It is committed to knowledge transfer to society and innovation in close cooperation with the public and private sector.

Key elements of the university's approach include:

- the creation and support of spinoffs and start-ups through the TOP (Temporary Entrepreneurial Posts) program, which has operated since 1984. With a target of 20 new companies per year, about 220 TOP companies have been established from 270 TOP posts, creating some 900 direct jobs. TOP companies form about 50% of spinoffs from the university. However, very few of these companies derive from licensing of university IP as opposed to staff/student initiatives. The Top program provides start-up entrepreneurs with support from university experts, use of university laboratories and equipment, office facilities, an interest free loan of £15,000,

access to potential clients through the university's network, business support and advice by experienced mentors, and training in entrepreneurship.

- Incubation support through BTC–Twente—a Business and Science Park located directly adjacent to the university, providing a full range of incubation support systems.
- A suite of capital funds, at the lowest level based on finance from the university and BTC–Twente, and progressively with greater contributions from government and the finance industry:

✯ Ondernemend Twente	NLG < 250K
✯ Technostarters	NLG 100–500K
✯ Innofonds	NLG 250K–1.5M
✯ Twining Growth Fund	NLG < 2M
✯ PM's Provinces	NLG 500K–10M
✯ PM's National	NLG 2–100M

The University of Twente founded the European Consortium of Innovative Universities in 1996 which now has eleven members across nine European countries. They share a commitment to:

- playing a catalytic role in developing an innovative culture in industry and society;
- building on strong ties with industry and the regions in which they are located;
- developing new methods of teaching and research;
- experimenting with new forms of management and governance;
- sustaining an international mindset among staff and students.

7.6 UniQuest Pty Limited, University of Queensland[82]

UniQuest Ltd was established in 1983 as the technology and consulting company of the University of Queensland. It is described as "a company, established to identify and package commercially valuable technologies and expertise from the University, and bring them to market via licences, venture capital funded start up companies, and consulting activities."

Performance was modest through the 1980's. However the University invested equity in UniQuest in 1995 for the purpose of building a professional team

[82] Based on http://www.uniquest.com.au and information provided by UniQuest

and implementing a research commercialisation strategy with a ten-year horizon. In making this investment, the University accepted that positive returns were unlikely inside five years.

UniQuest has not to date published annual performance measures, such as numbers of new disclosures, licences/options, and new patents filed, and commercialisation income, increasingly the practice of other university research commercialisation organisations. UniQuest intends publishing such criteria in its year 2001 Annual Report, to be released in 2002.

UniQuest does, however, report over 100 new IP disclosures each year (which would probably place it at the top of Australian universities for this metric), and more than 30 provisional patents. They currently manage more than 200 patent families of promising technologies.

The returns on the long-term investment in developing the research commercialisation capability of the University took off dramatically in 2001. Royalty and license income substantially increased from less than $2 million each year from 1998–2000, to more than $15 million in 2001. Likewise, the number of start-up companies established has averaged just over two per year from 1995 to 2000, but in 2001, there were nine, with more in the pipeline. Another report identifies a total of 29 direct spin-offs, 5 indirect spinoffs, and 2 technology transfer companies.

UniQuest is also a gateway to seed venture capital funding through its association with UniSeed—a joint company between the Universities of Melbourne and Queensland with an initial $20 million of seed capital.

A particular feature of the UniQuest approach is the decentralisation of IP identification and refinement to the Faculties. Managers, Innovation and Commercial Development have been appointed to each Faculty to work closely with the Dean on business development, sourcing deals and interfacing with UniQuest's headquarters' specialist staff. The positions are jointly funded by UniQuest, the University and the Faculties.

7.7 IMB.com, University of Queensland

IMBcom is an interesting example of the direct linking of research and research commercialisation within a common framework.

It was established at the same time as the Institute of Molecular Biosciences (IMB) at the University of Queensland, to act as an in-house driver of commercialisation of the internationally competitive research. IMBcom uses the IMB's unique pipeline of activities from genomics through to

pharmaceuticals to develop alliances with local and international companies, including Amrad, GlaxoWelcome, Pfizer, RIKEN and Alchemia.

IMBcom is also committed to the development of emerging technologies through the establishment of spinoff companies. Recently established spinoffs include Xenome (therapeutics based on venoms), Promics (broad anti-inflammatory drug leads), Protagonist (drug discovery platforms), Nanomics Biosystems, Mimetica and Kalthera.

The perspective shaping the development of IMBcom (and of IMB) is that an emerging world leading centre for scientific innovation must be matched by world leading practices in IP management and commercialisation.
A distinguishing feature of the model being developed is the close relationship between the innovators and the commercial/business specialists—in diametric opposition to the traditional model of arms-length separation, and involvement of the commercial perspective only when the research has generated the potential IP.

8 Towards best practice in university research commercialisation

There are five reasons why universities engage in technology transfer:

- *to facilitate the commercialisation of research for the public good;*
- *to promote economic growth;*
- *to forge closer ties to industry;*
- *to reward, retain and recruit faculty and students; and*
- *to generate income.*

All universities do it for the same five reasons; the mix is just different. And if you focus on the first four, you will get the fifth. If you focus on the fifth, you are likely to get nothing.[83]

8.1 New roles and their implications

Much has been written about the new roles of universities.[84] Once universities were concerned largely only with the custody and transmission of learning. After World War II, the generation of new knowledge by research became a central function. During the 1980s and beyond they were asked to expand their links with industry. Today they are asked to play a leading role in achieving an economic return from their research findings.

But transmission and dissemination of knowledge has always been a role of the university. Hence, it may be more appropriate to view these developments as new mechanisms, responsive to a changing world, to achieve age-old objectives. This is not to imply that the changes are trivial. They may well challenge some fundamental assumptions about universities. But they should be understood in this context of new mechanisms to fill traditional roles.

[83] Louis Berneman in a tele-presentation to a Research Commercialisation Workshop for the Higher Education Review Secretariat, DEST, 1 August, 2002.

[84] For example, Mustar, (2001), Etkowitz et al (1998)

One aspect of universities that may be particularly challenged by their involvement in research commercialisation is their governance. Their Acts, State Government auditing requirements, and the structure, authority, membership and practices of governing bodies may each raise, and in some cases have raised, evident inefficiencies, tensions and conflicts.

There is a need to review the elements of governance of universities to ensure they provide an appropriate framework to allow for, encourage and manage research commercialisation.

8.2 Some myths of commercialisation

We have found it necessary throughout this study in meetings with those not particularly well-informed about research commercialisation to attempt to dispel a number of well-established myths which impede understanding or effective action.

Myth No. 1 Universities are a vast untapped source of intellectual property.

They certainly contain a great deal of knowledge and scholarly individuals. But intellectual property is a rare asset, shaped by knowledge, the market and the rules of economics. Moreover, the process of transforming knowledge into intellectual property and then to a good or service is highly complex. Indeed, in many cases the process of research commercialisation is as creative as research itself.

Myth No. 2 Every time we license or sell a technology overseas we are selling the farm.

In a globally competitive world we must expect to sell a great proportion of the products of our efforts to markets overseas. This also has the benefit of linking us with global markets and operators, providing the basis of future economic activities. The challenge is to ensure we get a good price for our intellectual goods. And we need to understand that in the world of global intellectual property, a royalty of 7% is a very good outcome.[85]

[85] An ABC Radio National program http://www.abc.net.au/rn/talks/bbing/stories/s46352.htm complained that a royalty of "only 7% per annum" had been negotiated for Relenza—the flu vaccine. Rob McInnes has responded "what's the alternative? Is the ABC suggesting that a little Australian company should have raised a billion dollars in capital to pay for regulatory approvals, grown by a factor of 10,000 within a few years, established offices and a sales force around the world, built a pharmaceutical manufacturing facility in Australia and taken Relenza to themarket directly?"

Myth No. 3 Australian universities are way behind their overseas counterparts in commercialising research.

The data available demonstrate that the best-performing Australian universities are achieving research commercialisation outcomes broadly comparable with the best in the US and Europe, and way above their average. However there is considerable variability in performance, with a considerable gap to small and regional universities on the whole.

Myth No. 4 Researchers despise the very concept of business and wealth generation.

The great majority of academics with a substantial research performance (on average about half) have a very strong interest in seeing the potential outcomes of their research being realised. This realisation may take the form of a new course, a book, a performance, a new scientific theory, or a technology, such as the computer or the Internet, which will change the world. Some can generate direct commercial returns, while from others the economic return is indirect, and the social return considerable.

8.3 The national setting

Much has been written of the Bayh-Dole (University and Small Business Patent Procedures) Act passed in the US in 1980. It has been enthusiastically labelled the 'Magna Carta' of research commercialisation.

Based on recognition that "the failure to move from abstract research into useful commercial innovation was largely a result of the government's patent policy"[86], the Act provided for small business and non-profit organisations (including universities) to retain title to technology developed under federally funded research programs. It also created a uniform intellectual property policy for federal agencies. Universities were required to file patents on inventions they elected to own, and the Government retained non-exclusive patent rights and march-in rights. However the latter do not appear to have ever been exercised in the more than twenty years of operation.

The Act was associated with major changes on research commercialisation practice. More than 200 US universities now have technology licensing offices and pursue research commercialisation as part of their charter. The economic impact, referred to in Section 6, includes more than 270,000 jobs, 3000 new companies, $40 billion in product sales and $5 billion in tax revenue.

[86] Quoted in Siegel et al (2002)

However, a more cautious interpretation identifies that many other positive factors were operating at the same time eg. the IT and subsequently biotechnology revolutions. It was not simply a matter of passing an Act. Moreover, initial reactions produced target-hunting responses, with an increase in patenting but of lower quality, and an increase in secretiveness among researchers. This points to one of the fundamental tensions of research commercialisation:

Effective commercialisation requires non-disclosure. Effective research requires sharing of knowledge. Maintaining an appropriate balance is crucial for the success of both.

Australia does not face the situation of the US in 1980. IP rights are held by researchers or their institutions. Hence there is no apparent need for legislation. However, the kick-start effect of a major government intervention does warrant appropriate action.

The National Principles for Intellectual Property, appropriately strengthened, applied and monitored, together with encouragement to universities to establish broad targets, could provide the basis for significantly raising the profile and awareness of research commercialisation.

A second feature of the Australian national setting is the structure and capacity of Australian industry. It has been argued for the past twenty years that the structure of Australian industry is not the most appropriate to engaging with knowledge-intensive products. In key industries such as IT and biotechnology, there is little Australian industrial capacity. In these areas, the only existing companies to deal with are foreign. Furthermore, given that business investment in R&D is so strongly correlated with absorptive capacity, the low level of Australian R&D is a clear sign of structural weakness.

Hence there is a limited receptor or absorptive capacity in Australian industry for the IP emerging from the universities. The universities cannot be required to overcome these limitations through improved research commercialisation. Rather, as has been argued in our previous report, and by the ARC[87]:

This places a strong premium on following the spinoff/start-up route to research commercialisation.

Effective research commercialisation, and more broadly the capture of ownership and exploitation of intellectual property, has become of paramount importance in global competitiveness. Hence the traditional scientific commitment to sharing knowledge may be challenged by the drive for IP ownership.

[87] ARC (2000)

The recent announcement by the US National Institutes of Health that it would claim IP ownership in proportion to its share of funding in projects conducted outside the US threatened the IP value and ownership of all such projects. Fragmentation of ownership is a powerful deterrent to investors[88] Comparable IP ownership claims are also being made by the Wellcome Foundation.

Vigilance and appropriate policy may be necessary to protect the ownership of IP generated in Australia.

Against two key indicators, the level of research commercialisation performance in Australia is low. Whereas expenditure, publications and citations represent 2% of the world's scientific activities, US patents are only 0.75% of the total.[89] The level of revenue generated from commercialisation is only 0.16% of the total university budget. Performance against these measures clearly needs to increase. However, these are both lagging indicators. Changes which have already occurred, and which can be further accelerated, should produce a substantial improvement in performance.

8.4 Mechanisms for management of IP in universities

On the basis of experience in the US, Europe and here in Australia, the general characteristics of the business process necessary to support effective research commercialisation are well-established. The six stages are:

- achieving commercialisation readiness;
- scanning research activity to identify potential IP;
- option selection;
- option evaluation;
- negotiation of appropriate commercialisation and protection regimes; and
- management of the commercial portfolio.[90]

The first two stages are most effectively carried out through decentralised processes close to the researcher. The Flemish model of each researcher being required to maintain a record of inventions (Section 2) seems a useful mechanism.

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[88] A 12 month suspension of the introduction of this measure was announced at the beginning of August 2002 to allow time to explore the implications further.

[89] The use of patents in the US as an indicator of IP performance is obviously biased towards US residents. However the scale of the US patent system and the importance of access to the US market has led to this generally being accepted as providing a reasonable basis for international comparison.

[90] Johnston et al (2000).

But it is not a function to leave to the researcher alone. The UniQuest and Edinburgh Research and Innovation model of placing a 'commercialisation manager' in each faculty represents best practice, as they can play the roles of 'idea finder' and 'idea developer'. This is inevitably human resource intensive. But attempts to 'command' IP identification, or to achieve economies of scale by centralising the function, seem to be largely ineffective.

This suggests that the key focus for improvement is to raise the awareness and IP identification capabilities of research staff through training and other support programs. KCA and AIC may have a role in developing and promoting such courses.

The subsequent four stages need an effective centralised capability. Evaluations suggest there is a minimum threshold size of about three staff for such 'offices', that legal functions can be outsourced, that the emphasis and skills of the staff should be on business development, and there is a need for specialised industry knowledge. However universities with small research profiles cannot on their own afford or justify such resources.

What emerges strongly from experience is that if the research commercialisation function is set up without strong links with, and support from, the institution, it will be marginalised and, in all probability, fail. Research commercialisation is not simply an 'add-on' function; it requires a reworking of strategy and resource allocation to make it an integral part of the university's objectives and operations.

> *Examples of institutions that have succeeded or failed show…it must put a support structure in place: special training, venture capital funds, advisory structure, relationship networks. To be successful, a comprehensive system must be put in place. If an institution commits itself to this course, it must go all the way*[91]

[91] Mustar, 9.169 (2001).

8.5 Identification and development of investors and partners

The establishment of close links with relevant industry partners is one of the most challenging requirements of effective commercialisation. A review of the history of almost every significant university spinoff company reveals that relationships were built with appropriate industry from relatively early stages, well before any IP was identified.

Some venture capitalists are happy to provide leads or introductions to potentially appropriate industry partners. Research commercialisation offices can also provide this service if they have staff with the appropriate industry knowledge and contacts.

With regard to capital sources, there is now a reasonably effective venture capital industry in Australia, that regularly proclaims that it is deals and management experience that are in short supply, not capital. However venture capital is of limited importance to university research commercialisation. Few projects are of a scale or sufficiently close to market to provide the risk-return equation sought by venture capitalists.

What is most required are sources of finance to enable universities to hold their IP longer and develop it further, in order to obtain a greater return when they do license or sell. In particular there is a need for pre-seed capital to fund 'proof-of-concept' or prototype development, which is outside the responsibility of research funding agencies. Until recently, the only sources of finance for this crucial stage have been the external earnings of universities, or 'angel' investors. The establishment of pre-seed funding as part of the 'Backing Australia's Ability' program may alleviate this problem. However the scheme will need to be carefully scrutinised to ensure that the funds do flow to genuine pre-seed investments.

A particular tension to which attention should be drawn is that between the growing requirement for collaboration between researchers and institutions to achieve effective research teams and the requirement of venture capitalists for 'clean IP', where ownership is clearly determined.

The National Principles for IP Management should be revised to provide clear guidelines for the negotiation of IP ownership in cases where more than one institution is involved.

8.6 Criteria for selection of appropriate commercialisation strategies

Each university will need to set its own research commercialisation strategy, shaped by the available research talent, its areas of specialisation, its networks and its role in regional economic development. What is very apparent is that there is no 'one size fits all' model.

Within the institution, commercialisation strategies will also need to be selected as appropriate to the particular characteristics of the IP, industry structure and the market they are intended for. For mature industries and technologies, licensing to existing companies is likely to be the preferred route. For the newer industries and technologies, the spin-off route may be more appropriate.

8.7 Support mechanisms

Given the expectation that universities play a significant role in transferring research to commercial outcome, there is a need for substantial support mechanisms. This new requirement cannot be simply placed upon universities without recognition of the costs involved. While there may be expectations that the research commercialisation function can become self-funding, this does not happen quickly. Even the Stanford University TTO took 9 years to cover its costs.

Research funding bodies, with one exception, do not provide any support for research commercialisation. The ARC specifically excludes support for attendance at international conferences, where contacts with industry partners might be established. The NHMRC has established a modest competitive industry development grant to support proof-of-concept research. Both scientific and commercial criteria are applied in the evaluation.

Research funding agencies should examine their support for research commercialisation and consider establishing major schemes to assist with the costs of pursuing research commercialisation.

8.8 Collaboration

Research commercialisation success is largely driven by considerations of scale. Given the highly uncertain outcomes of commercialisation endeavours, effective management requires the establishment of a portfolio of projects and IP. The importance of scale has also been noted with respect to the research commercialisation office.

While these attributes of scale are fairly readily available to the larger and research-intensive universities, the smaller and regional universities do not have this capacity. This regardless that they well may (and do) possess pockets of research expertise capable of generating valuable IP.

Suggestions that they might purchase their research commercialisation services from a larger university are universally rejected. The competition is too direct. Solutions at a national or even State level have little prospect of success.

There would seem to be a need to encourage networking between smaller and regional universities to share their research commercialisation expertise. This might be a role for KCA and/or AIC and for case managers involved with local (eg. BITS funded) incubators.

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