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"The Devil is in the Detail – Making Sense of Risk and Trust in University – Industry Partnerships"

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THE DEVIL IS IN THE DETAIL - MAKING SENSE OF RISK AND TRUST IN UNIVERSITY – INDUSTRY PARTNERSHIPS[1]

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Abstract

University-industry partnerships (UIPs) are growing exponentially in OECD countries yet surprisingly, when one examines the research on cross-sector collaborations, particularly in R&D, evidence is inconclusive about what sorts of partnerships are more likely to succeed. This lecture explores the nature of UIPs and the risks associated with cross-sector collaborations involving the commercialization of R&D. The concept of risk has had a relatively short history in the study of R&D collaborations in general, and hardly any at all in the context of UIPs. The modern concept of risk pre-dates universities and in this lecture I explore three major risks that are now of concern to all universities arising from aggressive technology transfer policies. These include: financial risks, performance and relational risks, especially the importance of trust in UIPs, and reputation risks associated with the "public good" role of universities. There is much hype and "spin-doctoring" surrounding commercialization in universities. While it is not suggested that commercialization should be discouraged – far from it - the lecture does signal the need for universities to be far more risk oriented in how they go about it.

INTRODUCTION

Commercial activities of universities rarely receive good press, in fact, the opposite is usually the case, as any sampling of the media soon reveals. A lead article in *Business Review Weekly* (*BRW*) on July 20, 2001 ran with the headline, 'The ideas factory: Brains but no gains' and a by-line referred to Cooperative Research Centres (CRCs)[2] with the words, 'Great idea, shameful return' (Gome, 2001: 45-49). On Wednesday 29 May, 2002 *The Australian* went one better with the header: 'CRCs urged to change focus or die', and 'Suckers with a lemon taste', referring to the fact that prestige papers and PhDs were the main contributions made by CRCs to their host universities, for which the latter were contributing what was referred to as the "three Rs – resources, resources and resources" (Lawnham, 2002: 24). Commenting on one of the reasons why universities are so bad at commercialization, another *BRW* article entitled, 'Big science, little money', added to the negativity with which the media deals with the whole area of technology transfer between universities and the private sector (Quinlivan, 2001). Even if success does come from a spin-off venture, praise is likely to be mixed, such as was the case when two ex-Macquarie University academics sold off the successful IT spin-off, Radiata, to the US giant Cisco corporation in 2000 for $A567 million. Cisco had been a minority equity holder in the spin-off and Macquarie University and CSIRO[3] were to receive a healthy royalty

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[1] This paper is based on joint research and publications between the author and Associate Professor Paul Couchman from the University of Wollongong.
[2] Cooperative Research Centres were established in Australia in 1990 to encourage partnerships between industry, research institutes and universities in research consortia focused on applied research, research training and publications, though not necessarily commercialization. The emphasis, however, has switched in that direction over the last few years. Industry's role is to provide the expertise in commercialization. The principal funding body is the federal government though industry and university partners contribute to the program. CRCs, focused on public good research in areas such as sustainable tourism, have also been funded. The CRCs are only funded for seven years.
[3] The Commonwealth Science, Industry and Research Organization is a statutory authority whose primary functions were to carry out scientific research to assist industry, to further the interest of the Australian community

stream. Nonetheless, their critics were quick to paint it as a betrayal of Australia and tantamount to "selling off the farm" or Australia's future *Nokia* (Needham, 2000: 32). But all is not lost. In May 2002, the *BRW* published what seemed to be a positive piece entitled, 'Innovation - Professors of Profit', reporting on the surprising number of spin-offs launched over the last ten years by the CSIRO, universities and CRCs – in all, 229 of them (Gome, 2002).

The path to technology transfer is full of dangers and pitfalls, both in terms of economic returns and potential public relations disasters. At one time or another, Harvard, John Hopkins, Chicago and Boston Universities have all been embroiled in scandals through their commercialization ventures with the media having a feeding frenzy on them (Matkin, 1994: 372). The commercialization of knowledge, in whatever forms it takes, presents particular problems and risks for public sector agencies, their managers, the community of scientific/technical practitioners, and staff employed therein. In last year's *Sir Robert Menzies Oration on Higher Education*, the Vice-Chancellor of Auckland University, Dr John Hood, (a recruit from industry), who prefaced an interview with the comment: "industry values are not too dissimilar to those of the university" (Madden, 2001: 24), cited both risk and complexity as the two main issues that arise from commercialization, or what he termed euphemistically, "alternate revenue streams" (Hood, 2001:10-11). By definition, he said, risk and complexity mean that things will not turn out as planned and this will cause pain and be expensive too. The excursion, he said, into the foreign terrains of business and capital markets, requires new managerial responses within universities.

It seems odd to think of university and industry as the same because, when it comes to commercialization of R&D, there is overwhelming evidence that managing risks (shifting, spreading or plain avoiding them) is a major preoccupation of the private sector. We know a lot more about the economic motives behind private sector research partnerships than we do about cross-sector collaborations such as UIPs. What we do know is that different industry sectors have differing expectations and needs from partnering. (Hagedoorn, et al., 2000; Cohen et al., 2002; Tidd et al., 2002). We also know that universities around the world are aggressively seeking UIPs to raise revenues from non-government sources to fund R&D and diversify revenue streams. All OECD countries have developed policies to make universities part of national agendas to improve the competitiveness of businesses and the community at large through technology transfer, innovation and commercialization to meet national priorities of social and economic advancement (Lee, 1994; Rosenberg and Nelson, 1994; Rappert et al., 1999). Competitiveness, commercialization, cooperation, collaboration and partnerships have been made synonymous with wealth creation and the national good. To question such honorific aims seems implausible, though rumour has it that at least one VC in Australia is known to be anti the "C" words. Government, and not universities *per se*, is most responsible for the emphasis placed today on the value of university intellectual property (IP) as a commodity, though academics seem to receive the bulk of the criticisms for the growing emphasis on commercialization (Rappert, 1999: 882).

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and facilitate technology transfer to the private sector. Over the last few years it has embarked on an aggressive push to commercialize public research and improve its revenue stream.

Much is yet to be learned about research partnerships, particularly the commercialization of R&D in universities and the risks posed by aggressive technology transfer policies and practices. However, the study of risk in collaborative arrangements is still a developing area (Das and Teng, 2001: 277), and hardly touched is research on cross-sector collaborations (see Harman, 2001). I intend to explore this further in terms of the major risks involved in UIPs, especially from the perspective of university partners. I will look at the specific issues associated with commercialization and technology transfer and the challenges these present for universities. This leads to consideration of the financial risks that commercialization poses for universities that are, in fact, different to those of the private sector. Third, I examine factors associated with the relational and performance risks arising in UIPs. Finally, no discussion of risk in R&D commercialization is complete without looking at the potential dilution of the "public good" role of universities, and the reputation risks inherent in the marketization of universities.

There are valuable lessons to be learned from viewing UIPs from the perspective of managing risk. By focusing on risks, I am clearly declaring my hand. This lecture is not about the benefits of UIPs because it is my view that the "spin doctoring" coming out of universities and government circles seems to paint commercialization and UIPs as the panacea for all the woes facing universities under continuing budgetary constraints. My worry is that the risks seem to be pushed into the background or only mentioned with dutiful note and quite obviously with the subtext being clear – the devil is going to be in the detail but let's worry about it later.

Some of the Detail

The concept of "risk" actually emerged during the period of modernity, well after universities were formed, and has been central to economic and business discourse since the 18th century. As Giddens (1990, p. 34) has observed, the notion of risk has to a large extent replaced the idea of fate in human affairs and this:

> …represents an alteration in the perception of determination and contingency, such that human moral imperatives, natural causes, and chance reign in place of religious cosmologies. The idea of chance, in its modern senses, emerges at the same time as that of risk.

It was in the new discipline of political economy that the discourse of risk became associated with profit. The chance an entrepreneur took in an investment venture was seen as the source of any profit obtained, and the higher the risk taken the greater the potential for profit (e.g. in 1848 John Stuart Mill argued *"… the difference between the interest and the gross profit remunerates the exertions and risks of the undertaker"*). Consequently, the investing entrepreneur takes a risk (i.e. exposure to the chance of loss) in the expectation of a return on the investment, but this can be a "calculated risk" in that the entrepreneur may be aware of the threats facing a chosen course of action. Of course in those days, the entrepreneur was investing his/her own money. However, herein lies the fundamental element of risk management in contemporary managerial discourse: to identify, evaluate and take action to manage risk is to act "rationally". Alternatively, to use more everyday language:

> Coming to terms with risk does not mean eliminating risk from our lives, which is clearly impossible; nor does it mean that we should do nothing about risks and accept consequent

> losses fatalistically, as if we could have done nothing about them. It means that we must manage risk: we must decide what risks to avoid, and how we can avoid them; what risks to accept, and on what terms to accept them; what new risks to take on, and so on (Dowd, 1998: 3).

In the whole area of risk management, universities are at a considerable disadvantage. The assessment and management of risk have longer histories in the private sector (e.g. in insurance and financial management), and it could be argued that many public sector organizations are novices in this field, as they are often inexperienced in key areas such as raising venture capital, forming joint ventures, managing equity funding, a portfolio of shares and many other aspects of R&D commercialization. Yet this is now the area into which universities are entering and potentially becoming competitors with other private sector players.

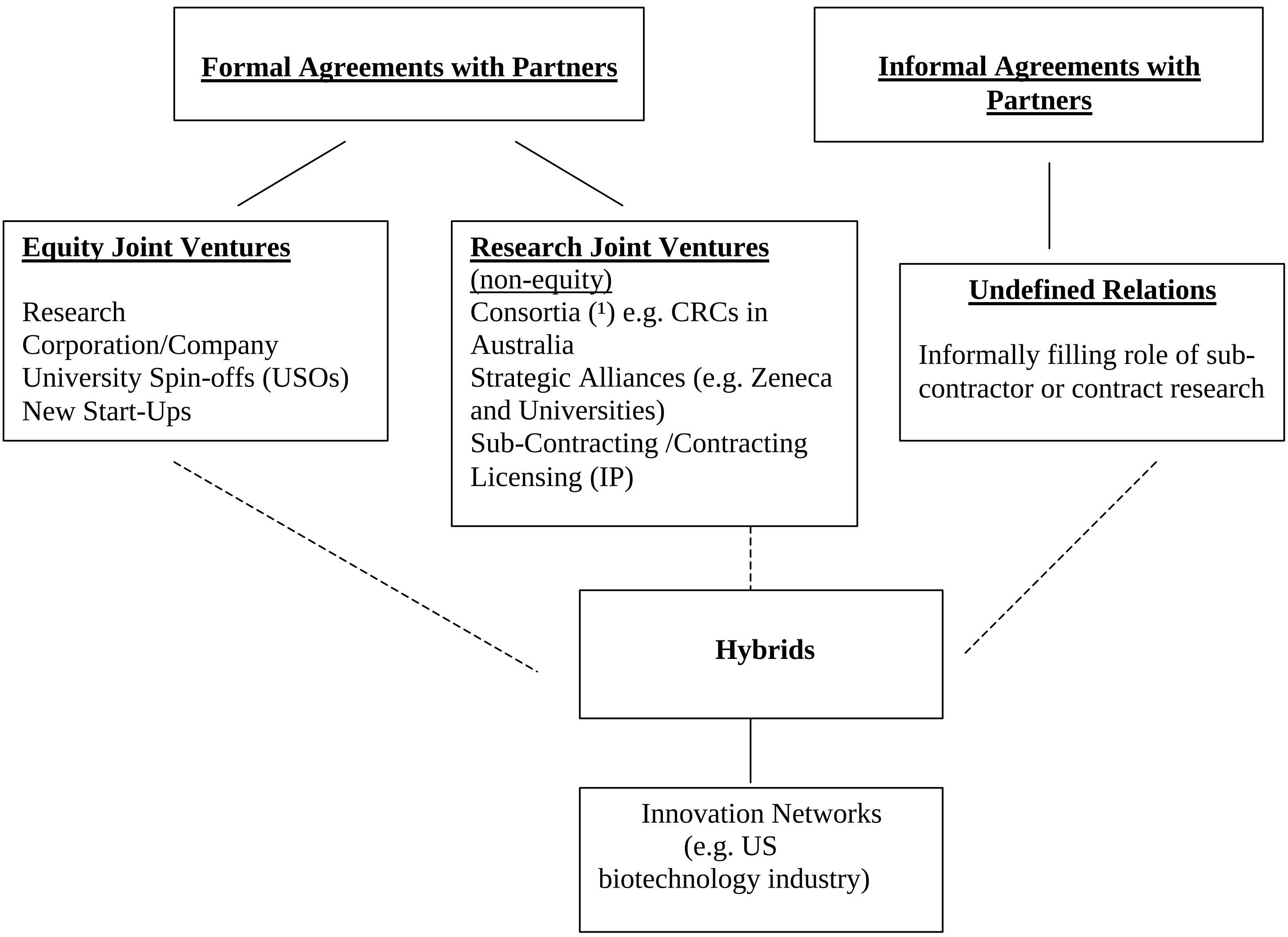
However, it is evident that the risks of commercialization, especially aggressive technology transfer, have not escaped the attention of some very distinguished academic leaders. In 1982, the President of Harvard University, Derek Bok, declared that the most controversial aspect of the University's collaborative partnerships was the decision to either assist or not assist professors to form companies to exploit their discoveries. Bok asserted that, on balance, the financial advantages of these partnerships appeared more speculative than had been thought, while the dangers to academic science seemed real and severe (Feller, 1990: 336). Six years later the headline in the *New York Times* read: 'Harvard to Seek Research Profit', and reversing Bok's decision, it embarked on the strategy to form limited partnerships to raise $US30million to bring faculty research to market.

A seminal paper, published 1990 on the reversal of Bok's decision, observed critically that research universities in the US were moving beyond traditional forms of R&D partnering, and increasingly engaging in what was termed "active technology transfer" (Feller, 1990:335), which others referred to later as "full-service technology transfer". This form of transfer involves: "…accepting equity in licensing companies, in addition to cash royalties, funding the development and expansion of nascent technologies (the 'funding gap'), and – the last frontier… – starting up companies to exploit technology developed by the university" (Matkin, 1994: 372). While the author did not question that academic research contributed significantly to technological innovations in industry through transfer and development of basic findings or as a basis for spin-offs, he did question the infrequency with which commercializable products were the end result (Feller, 1990: 337). He also questioned the aggressive push by university administrators to reach into laboratories to extract commercializable knowledge.

There are certainly contradictory findings on the role of university research in industry development and successes with commercialization (Feller, 1990; Cohen et al., 2002). In the Introduction to a *Symposium on Technology Transfer* published in 1994, the observation was made that, despite a decade of effort, little was known about "…what worked and does not work, and under what circumstances, and why", in respect of technology transfer. Moreover, "the jury" was still out on the conflicting policy agenda of full-service technology transfer (Lee, 1994: 265). Again, we might say that was 1994 and things must surely have improved by now. Well not so, because in the Introduction to a *Special Issue* on *University Entrepreneurship and Technology Transfer* published only this year, the authors lamented that the whole area of university commercialization remains poorly understood in the US (Mowery and Shane, 2002: ix). It concluded that there was much more research needed in the management aspects of university commercialization both in the US and overseas (see also Prabhu, 1999). This begs the question of what does commercialization mean in the context of universities, and more generally, in UIPs.

In this lecture I am using the term "UIP" to cover research partnerships involving cooperative relationships between companies, universities, government agencies, private research institutes and small businesses that are formed to pool resources in the pursuit of shared goals aimed at innovative outcomes (Hagedoorn, et al., 2000: 568). *Figure 1* shows how these relationships are formed as joint ventures of either an equity or non-equity kind, and the degree to which they are formal (i.e., have binding agreements or contracts) or informal (Hagedoorn, et al., 2000; Tidd et al., 2002).

Figure 1: Research Partnerships



Adapted from: Hagedoorn et al. (2000); Tipps et al. (2002).
([1]) Can include joint facilities for R & D or conduct R & D in mentor firms or University.

COMMERCIALIZATION

Commercialization is the process whereby research outputs and inventions are commercially exploited in the form of marketable goods and services or production processes (i.e. whereby knowledge is translated into commodities). Research outputs include formal codified knowledge ("know how") as well as tacit knowledge, and the ownership of these outputs as "intellectual property" may be formally protected as patents, copyright (including computer software), eligible circuits, and registered designs as well as trade secrets. The nature of the technology, and the regime of appropriability in which it exists (i.e. basically how hard or easy it is to protect IP), affect the commercialization of R&D. Patents do not work well in process technologies, for example, where a slight modification (i.e. "invented around") can alter the IP, and where IP agreements are hard to enforce and legal remedies are too costly (Teece, 1986: 287). Commercialization involves the transfer of knowledge (e.g. as embodied in a material technology such as a working prototype) and its conversion into marketable products and industrial processes. For university-based research, this process can be achieved via a number of channels, the most popular being through contract research and consultancies specifically devoted to commercial outcomes or through the licensing or assignment of IP resulting from the research. It can also include equity holdings, through to the creation of university spin-offs (USOs)[4] created specifically to exploit the IP produced. Other forms of partnering are also popular and the most common being research consortia (Tidd et al., 2002), such as CRCs in Australia. To commercialize means using IP in conjunction with other capabilities and assets, such as marketing and sales, manufacturing, after sales support, specialized facilities, and dissemination through specialist channels, as in the case of drugs. Additionally, the critical choice is whether the innovation is developed by contracting out the IP or being internalized and integrated within the organization (Teece, 1986).

There is also a narrow and a broader view of the commercialization of research. The narrow view, and the one that has tended to dominate in policy debates, focuses on the protection of new IP and the exploitation of this by way of new products and processes and the creation of USOs. A broader view of commercialization, is based on a view of innovation as " … complex, uncertain, somewhat disorderly and subject to changes of many sorts …" (Kline and Rosenberg, 1986: 275), and acknowledges a wider range of less tangible economic benefits that can arise from research. Thus, in this view, commercialization is seen as:

> …a heterogeneous process that often involves incremental changes in materials, products, or processes. It often involves investment in new equipment, facilities, or skills. Its economic impact may arise from the production or investment decisions of only a few firms or of many small producers or users. The time scale from development to application to economic returns may span a few years or be measured in decades. Commercialization may include, for example: changes in instruments and data interpretation that lead to the discovery of new resources or new treatments for diseases; processes that result in a higher recovery of gold from ore, or higher quality welding on ships and pipelines; improved product design and quality (Mercer and Stocker, 1998: v).

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[4] A USO is a firm whose products or services have developed out of technology-based ideas or scientific technological know-how generated in a university setting by a member(s) of staff or student(s) who found or co-found the firm. It involves the individual(s) leaving the university to start the firm or starting it while still inside the university (Rappert et al., 1999: 874).

Some argue that the broad view is going too far. They suggest that universities should stick to what they know best, and heed the advice of industry that what they most want from universities is for them to open up new areas of knowledge and provide specialist advice and help (Rappert et al., 1999: 888; also Rosenberg and Nelson, 1994). There are no wins in these two positions for universities given the realities of government pressures. What seems more important is for universities to understand what types of knowledge exchanges matter for particular industry sectors and the conditions that support these exchanges, such as IP arrangements, informal channels or other forms of partnering, and work to diversify how they go about commercialization and partnering. This means accepting that no one model of commercialization or technology transfer will fit all (Rappert et al., 1999: 888). Thus, in some fields, basic research might be critical and in others not, or in some the distinction between basic and applied research might be irrelevant.

In specific knowledge-intensive industries, such as biotechnology and pharmaceuticals, companies have become ever more reliant on public science (McMillan et al., 2000). There are two main reasons for pharmaceutical companies collaborating with universities. The first is that most of the leading-edge work continues to be carried out in public sector laboratories and thus they remain a critical source of new scientific and technical knowledge. The second is that in biotechnology the distinction between basic and applied research is somewhat blurred, so advances in the former can lead directly to products with commercial potential (Tapon and Thong, 1999). Another major reason for this trend arises from the nature of scientific progress:

> …. [In] biology and chemistry as in other technological fields, abrupt innovations stemming from serendipitous discoveries arise regularly and will take on increasing importance in the future. Because it is impossible to predict where they will occur, the only way pharmaceutical firms can take advantage of them is to build a vast network of research relationships with university and independent laboratories where these serendipitous discoveries occur (Tapon and Thong, 1999: 220).

Risks in Commercialization

A key question in all forms of knowledge transfer is who should bear the risks of R&D? The major risks in R&D are not those associated with basic discovery but the development phase of turning an invention into a marketable product. To undertake technology development effectively requires someone to “de-risk” a new, break-through scientific discovery and prepare it for commercialization. To de-risk an invention means creating a market pull for it and making it technically feasible and cost efficient (Lee and Gaertner, 1994: 389). Creating a market pull means making the invention attractive to the market and to potential investors, i.e., by adding complementary assets to the process that many universities do not have or are only now acquiring. In addition, to commercialize an invention requires that it be meritorious in that it has the potential to create a new market and grab market share (Lee and Gaertner, 1994: 338). The gap between conception and commercialization is often referred to as “pre-commercialization” (or the funding gap mentioned above) where investment attractiveness only rises if risks start to fall. Even if the invention has been prepared for market, a host of contingency factors bedevil all innovations (Lee, 1994: 396). These can include: the structure of markets and shifts within them, sometimes quite dramatic, the behaviour of venture capital markets, availability of entrepreneurial experience and business acumen, and of course, any number of policy changes and constraints provided by governments. The highest yielding returns, as well as the highest investment by the private sector, are in specific fields such as biotechnology and pharmaceuticals, where the chances of successful commercialization are also the lowest (Casper, 2000: 901).

In therapeutic drugs, a ten-year innovation cycle is the norm and involves several stages of clinical trials before US Federal Drug Administration (FDA) approval is sought. On average, 20% of funds are spent on discovery or basic research and the remaining 80% on development of candidate compounds, as well as pre-clinical and clinical trials with the likelihood of only 5% of drugs being approved to proceed past the pre-clinical trial stage (Casper, 2000: 897-900). The total estimated cost of developing a new drug is between $US100-200 million with a high rate of failure amongst new start-up companies who bear the brunt of the development costs. Given the high technological uncertainty (i.e. low appropriability) and the "racing" activity of other firms or alliances to be first to market, technology development is risky indeed. A new drug is usually bought to market through alliances with established pharmaceutical companies who, overtime can appropriate the knowledge and become a potential competitor to the alliance or the USO (Casper, 2000: 899-901). For all firms, the "golden rule" is that in-house capabilities represent the knowledge base for innovation and competitiveness and only in a select few industries would this not be the case, such as cutting-edge research (Rappert, et al., 1999: 877). It is a mistake to see the world of commercialization through the lenses of biotechnology and pharmaceuticals, as I think a lot of universities are doing at the moment.

Technology Transfer

Technology transfer happens in a number of different ways, and varies across industry sectors, regions and even countries. It occurs via diffusion and adoption and this can be facilitated by relatively free market exchanges in the form of information dissemination, in particular conference presentations, journal publications, education and training and other non-privatized forms of knowledge exchange – all areas in which universities excel (Lee, 1994; Rappert, et al., 1999). These observations are borne out in data from the Carnegie Mellon Survey conducted in 1994, the largest of its kind, and published only this year on industrial R&D, and the perceived contribution of public laboratories and universities to industrial innovation in the US. *Table 1* reveals that the average scores across two factors for channels of technology transfer showed that publications, informal interaction, public meetings and conferences loaded the highest on the first factor (Cohen et al., 2002: 17-18). These are all low cost ways to tap new knowledge through weak ties (Rappert et al., 1999: 877).

The study also reveals marked differences between industry sectors (i.e. the technologies and markets involved), and large and small businesses in how they appropriate knowledge from university research with pharmaceuticals and small biotechnology firms being the heaviest users of public R&D. Biotechnology has developed, at least in the US, from within universities with strong links to small biotechnology start-ups and USOs clustered in two major innovation networks in Boston and San Francisco (Feller, 1990: 338; Rosenberg and Nelson; 1993: 343; Casper, 2000; Cohen et al., 2002: 21; Hage and Hollingsworth, 2000).

Table 1

Industry-Level Factor Analysis of Channels-of-Information Flow from Public Research to Industrial R&D

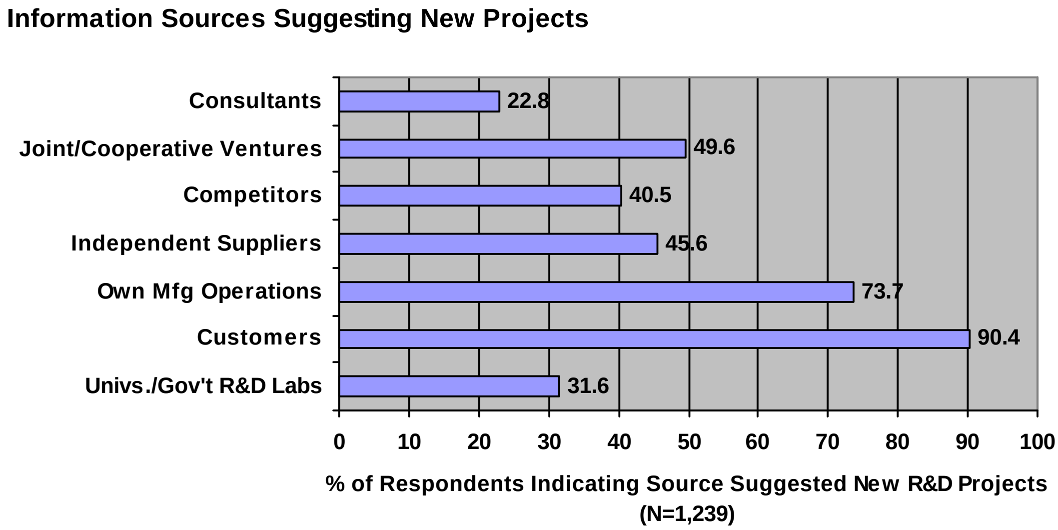
	Factor Loadings	
Channel	Factor 1	Factor 2
Publications/reports	**0.85**	0.04
Informal interaction	**0.84**	0.09
Public meetings or conferences	**0.84**	0.16
Contract research	**0.79**	0.23
Consulting	**0.70**	0.23
Joint or cooperative ventures	**0.63**	0.29
Patents	0.34	0.20
Personnel exchange	0.00	**0.70**
Licenses	0.21	**0.69**
Recently hired graduates	0.25	**0.51**
Eigenvalue	3.87	1.49

Adapted from Cohen, W. M. et al. (2002), p. 17.

An earlier study in the US also confirmed a heavy dependence by industry on basic research generated for new product and process developments. It also concluded that the economic payoffs from basic research were higher in the US than other nations (Mansfield, 1990; Rosenberg and Nelson, 1993; 343; Cohen and Noll, 1994: 61). A more recent study conducted in the UK on USOs found that in certain sectors, such as IT and scientific instruments, universities were actually clients and the first market contact for a new product. In other fields, such as materials, more direct use of equipment, feasibility studies and exchange of materials were quite important. Different forms of knowledge, categorized into fourteen main areas, were appropriated by the USOs, with IT and scientific instruments, for example, being most dependent on universities for new product ideas (Rappert et al., 1999: 878- 81).

Under more direct market oriented strategies, as mentioned in *Figure 1*, technology transfer is undertaken through various routes such as direct investment, licensing, contract research, R&D consortia and alliances, research companies, such as spin-offs or USOs, and research parks or networks (Lee, 1994: 261; Hagedoorn, 2000; Tidd et al., 2002). Universities have historically used arms-length relationships, such as licensing and contracting, and have only, in the last decade, moved to less-than-arms length relationships. *Table 2* shows findings again from the Carnegie Mellon Study relating to the role of university R&D in generating new projects in industry. In descending order, the largest contributors to developing new projects were customers, then the firm's own manufacturing operations followed by joint ventures with universities, with university and public research laboratories coming second last (Cohen, et al., 2002: 5-7). Competitors ranked higher than university and public laboratories in generating new projects. In terms of completing projects, the pattern was repeated except that competitors dropped to 11.7%. The study noted marked industry variations and differences in the types of knowledge being accessed.

Table 2 – Information Sources Suggesting New Projects



Adapted from Cohen, W.M. et al. (2002), p. 6.

Benefits of university research to industry can involve a lag time of twelve years in undirected research, but reduced to an average of five years through collaborations. Collaborations increase future industrial research in many cases and speed up technology transfer to industry, so for industry there is an overall gain from collaborative research. However, even a five years lag time can be very long in terms of political and program standards (Berman, 1990: 354), as well as industry expectations.

We also should not assume that all universities go along a pre-ordained commercialization trajectory. There was a period when MIT's governing body made a decision to cut back on industry focused research and concentrate instead on more scientific-discovery based research, and this led to an increase in research dollars and a higher academic standing (Feller, 1990: 342).

FINANCIAL RISKS

The reality is that universities cannot efficiently engage in technology development and commercialization under normal R&D funding because the expenditure for development work far exceeds normal disciplinary based funding (Lee, 1994: 390), and there is no sign that commercialization will become less important. Universities have several choices. They can: (i) license, assign or sell IP and charge royalties or a high fee; (ii) support a USO and hive it off, or (iii) use equity agreements (based on how much stock the university receives for the right to use the technology) to take a stake in an existing business or start a new one (Lee, 1994: 391; Feldman, et al., 2002; Cripps et al., 1999: 151-2). They can also use a combination of these strategies in a single venture.

There are risks associated with all of the above. For example, a recently reported study of licensing practices in MIT, found that licensing to non-inventors was more likely to lead to commercialization than back-licensing to the inventor in the university, and that the type of technology involved played a major role in attracting investors (Shane, 2002a: 133). Moreover, returns to universities on royalty payments have been generally poor because embryonic inventions are often licensed, and premature licensing can ruin the chances of an invention being commercially successful, and amounts to a loss in future revenue (Clyvas et al., 2002: 67). As a "rule of thumb", for every one hundred disclosures of an invention, only ten patents emerge of which one leads to a commercially successful product. Successes are few and skewed to a few big ones with many more mediocre performers (Feldman et al., 2002: 108, citing Blake, 1993).

Equity agreements have risks associated with the stock market but have high appeal because if an initial public listing (IPO) is successful, the rewards can be significant and ongoing. They also provide universities with greater control over how the technology is developed without resorting to protracted contracting and speculative costing involved in negotiating IP rights and licences (Feldman, et al., 2002). Equity holdings create enormous potential for all or one of the following to occur: conflicts of interest and potential unethical behaviour; institution-wide conflict over who benefits from such commercial ventures and the legitimacy of these activities in general; disputes over how to raise funds for new ventures and how to underwrite them; disputes over who bears the losses and the liability if the company fails or is sued; and how to manage the bad publicity should it arise (Feldman et al., 2002: 107; Matkin, 1994). Finally, there is no clear-cut evidence, as yet, that university equity holdings lead to commercial success. Often such holdings are developed in the absence of commercial interests usually because the latter are not impressed with the invention's profitability, making such ventures quite high-risk propositions (Shane, 2000, cited in Feldman et al., 2002: 112).

Technology development and commercialization pose major challenges for universities in terms of potential financial losses and mismanagement. Collaborating companies are also exposed to these possibilities, but the impact for the public sector partner is far greater on a number of scores. Any failure or financial loss will usually be a very public affair because the media, along with politicians, rightly take a special interest in the use of public funds in terms of accountability and public perceptions. In May 2002, the fourth inquiry in as many years was established to specifically investigate levels and sources of income, financial management and accountability, including the use of taxpayer's money to fund commercial activities within universities (Illing, 2002: 29; Contractor, 2002: 9). Again, in December 2000, the headline read: 'What's the big idea?' reporting a $A6 million loss by Anutech (one of the Australian National University's (ANU) spin-offs) that prompted a Senate inquiry into whether or not taxpayer's money was being used to underwrite these sorts of losses (Contractor and Noonan, 2000: 9). This of course suggests it is easy to disaggregate where private and public funds begin and end in universities today with many of them having substantial private revenue.

The article went on to reveal that the portfolios universities had been developing were usually far more meagre than professional investors would advise. It pointed to the limited financial capacities of the university sector to spread risks in a commercially responsible way. Of course, professional investors see the answer in universities employing their services and other financial experts, adding more costs to commercialization strategies, with no firm guarantees things will improve. Universities were also criticized for being secretive about their joint venture equity deals and hence, lacking transparency. They were also reprimanded for being selective in how they reported revenues, usually opting not to disclose surplus of revenue over costs, which would show a far worse picture (Contractor and Noonan, 2000: 9). If we go back to the 'Professors of Profit' story, it revealed that universities with a research budget greater than $A100 million, on average, spent $A131 million on creating a spin-off and those with smaller budgets, in the range of $A20-99 million, spent an average of $A333 million on each spin-off. While these rates compared favourably with the US (Gome, 2002), they do raise questions about potential revenue streams. A number of ventures have been successful, based on indicators such as net present value or potential market capitalization (Quinlivan, 2001), but some would dispute these assessments.

Hidden Costs

Accounting systems in many Australian universities are not geared to the needs of commercial activities and the methods of costing used in universities involve complex forms of cross-subsidization and cost shifting from productive to less productive units, making transparency and accountability difficult. It would be well nigh impossible to get real time financial reports in universities. Universities focus on revenue projections because the costs associated with commercialization are difficult to disaggregate in highly complex accounting systems that are also driven by complex funding formulas. Universities cannot easily report in terms of the opportunity costs of their commericalization activities because of the cross-subsidization regime that has to operate to provide essential support services and other activities under legislation and funding agreements. Any notion of what constitutes a healthy return on investment, is also a difficult concept to apply in many universities, as illustrated by one VC, who commenting on the losses in her university's spin-off, lamented that it had performed well in the past and it was unfair to focus on a bad year (Contractor and Noonan, 2000: 9).

One of the key features of R&D is that it has very high fixed costs. Every activity involving a scale-up in R&D, especially full-service technology transfer, will add fixed costs that have to be recouped to make the venture profitable and this has to occur over a reasonable time frame (Feller, 1990: 34). Fixed costs can be associated with attracting top researchers by providing them with state-of-the-art equipment and facilities, as well as other "add ons" that increase variable costs. Harvard's decision to reverse Bok's stance was in large part influenced by the desire to retain top medical researchers (Feller, 1990). Variable costs also rise with commercialization through increases such as in lodging patents and having to manage them through the complicated process of approvals, possibly having to defend them through litigation in failed ventures, meeting auditing and reporting requirements, employing the expertise needed to raise venture capital and managing equity holdings, to name a few. Often these costs are not internalized in any particular venture and therefore the profits and losses are hard to work out.

Commercialization is particularly risky within universities because, unlike the private sector that has, in theory, the financial discipline of bottom line profit strictures to keep them generally altered to bad investments and to activities that have to be discontinued, universities have largely escaped such market discipline. As one observer notes, it is not readily apparent that universities can recognize early enough their bad investments or be able to easily pull back from the commitments they have made (Feller, 1990: 346, citing Nelkin and Nelson, 1985: 33). In part, this flows from the lack of market signals for universities, the focus on efficiency in non-market organizations instead of on effectiveness of resource utilization, and "…the tendency to use too many resources relative to output or seek to produce too much relative to foregone alternatives", which might explain the surge of interest in commercialization and revenue streams (Feller, 1990: 346). This lack of discipline means that universities are unlikely to extricate themselves easily from financially unprofitable ventures (Feller, 1990: 346).

Risk Shifting and Costs

We also need to focus on risk and costs in partnering from industry's perspective. The major motivation for companies to enter into R&D collaboration, in general, is to minimize the costs and risks associated with the high levels of uncertainty of doing R&D. From an investment point of view, this is a "de-risking" strategy; but from the perspective of UIPs, it represents a transfer of risks from one sector to the other. On this score, it is interesting to consider how pharmaceutical companies view their partnerships in terms of risk and cost issues. It is suggested that one reason for collaborating is to learn new capabilities from partners with a view to transferring in-house those that become core to the company's business (Tapon and Thong, 1999: 225). Another is that external collaborations help a company to gain knowledge about the costs associated with other forms of R&D and the trade-offs needed to enter a new field, without having to put the company at risk in a new field because someone is else is conducting the research. Still another is that if the resources needed for a particular technology development are prohibitive in terms of costs, then the collaboration can be terminated within the provision of the contract, without harming other parts of the company or sending the wrong signals to customers. Finally and most importantly, the risk of failure or pursuing dead-end research can be shared with another partner while allowing the company to undertake a greater number of research projects than would be possible with its own resources (Tapon and Thong, 1999: 226).

Universities subsidize industry R&D in more indirect ways that are not factored into the costs of UIPs. A study in the US estimated that to produce cutting-edge technology would cost about $US240,000 (at 1994 values) but that it would have cost double that to do the same work in industry. Not only this, academic scientists build on their basic research adding significant value in new knowledge (or intellectual capital) that they bring to projects. This form of value-adding is not costed on the basis of what similar expertise would cost in the market place, if it was available (see also Leyden and Link, 1999: 581). However, the greatest cost advantage identified by the study was the use of graduate and postdoctoral labour in research projects whose rate of compensation would be roughly 150% in the private sector compared to a loading of 42% in universities (Lee, 1994: 395-6). Our case study on the "SEE3" contact lens (which had been developed in a cross-sector collaboration involving a CRC with multi-national partners in Australia, and is if often referred to as the "Eye CRC") showed how a major multinational corporation was able to gain access to a wider range of resources, as well as tap into the latest scientific developments, far more cost-effectively than if the corporation had conducted the product development entirely in-house or in collaboration with another company (Couchman and Fulop, 2000; 2001).

What the media and others usually ignore is that, on balance, company resource allocations to collaborative ventures are often relatively modest, so they represent fairly insignificant amounts of funding compared to the company's overall budget, and hence any losses are much more financially manageable (in most regimes, such losses can even be written off as tax deductions). This contrasts markedly with the situation for public sector organizations. In times of financial constraint, as is the case for most public sector research agencies and universities in countries such as Australia, the UK, and the other European nations (where government funding is mostly being reduced and where its future levels are uncertain), committing a substantial body of resources to a venture, which is at risk of financial loss, can lead to major problems. The nature of these problems can be illustrated by the recent experience of the commercial and consulting divisions that have been established by most Australian universities. As stated above, a number of these bodies have incurred large losses in recent times, and these losses can require cross-subsidization from the mainstream of university funding and, in the Anutech case, the university allocated $A4.7 million from its general budget to help cover some of the loss. These costs represent a significant proportion of a university's overall budget, and, where the losses are large, they can have a major impact on other areas of activity (Quinlivan, 2001: 70). Some universities have had success with equity holdings but these have so far been few and are still considered too risky for this sector (Quinlivan, 2001), and likely to continue to be so given the volatility of the share market.

While financial risks will remain a major issue in UIPs and commercialization, we ought not to forget that, as the great management guru, Peter Drucker reminds us, only fifty years ago no-one would have imagined a university department and a private sector company jointly working on commercialization (Drucker, 2001: 15). It is only in the last ten years that US industry has moved away from significant investments in in-house discovery research to concentrate on product development and design (Buderi, 2000). Universities are responding to massive commercial changes and reforms are being made to accommodate commercial practices. Industry has been at this since about the fourteenth century, with the greatest break-through for a number of centuries being double-entry accounting! Universities need time to gear up to commercialization and even sometimes to pull back if the risks become too great. However, universities are not the commercial pillars of society and nor should they be judged or treated as such. They are contributors to it, but also to a whole range of other services as well. A lot of what they do still cannot be done on a strict cost recovery basis and with the discipline of markets in mind, and this might never change.

PERFORMANCE AND RELATIONAL RISKS

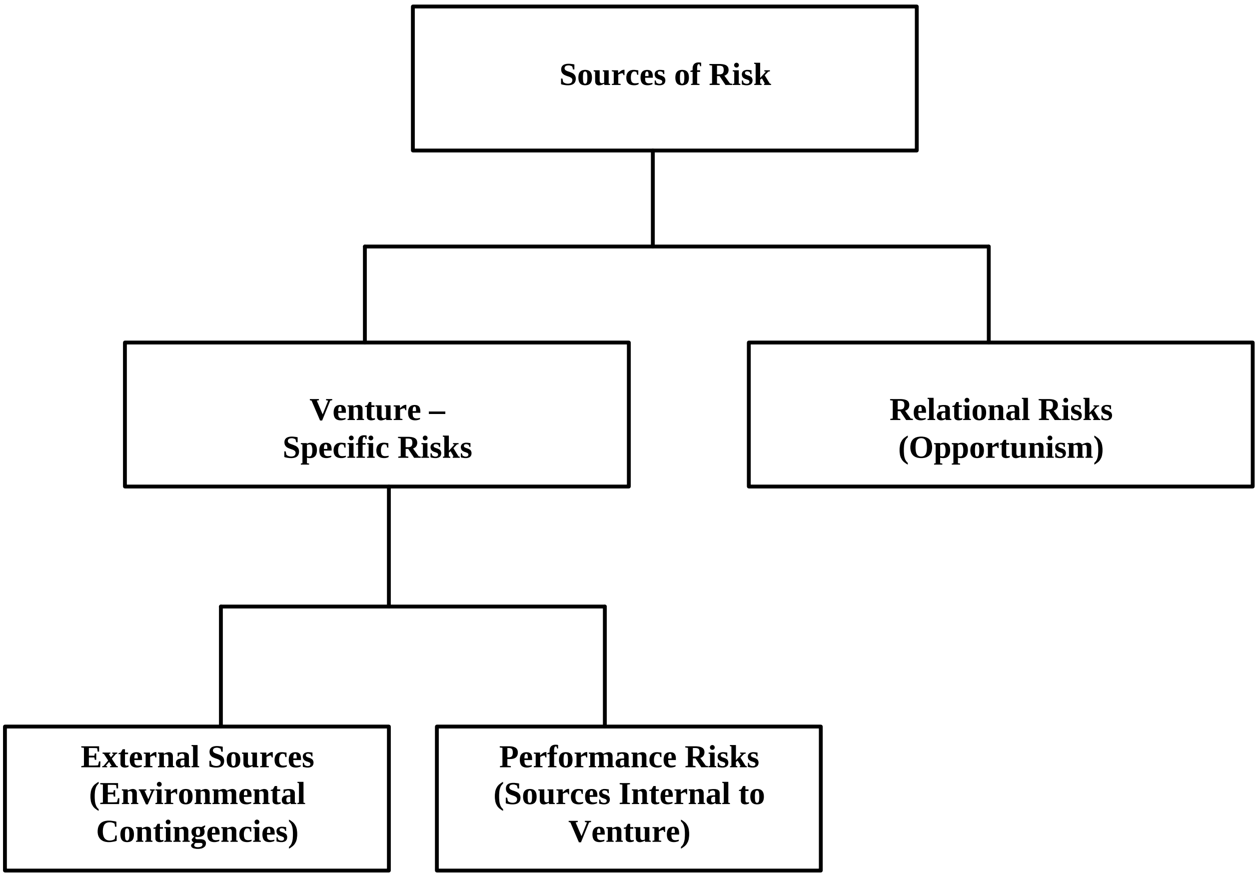
As noted by a number of commentators, interorganizational collaboration (IOC) is a "risky business", and there have been high levels of failure and dissatisfaction with the outcomes across all sectors. Commenting in 1996 on the state of UIPs in Australia, Mann observed that "…[t]he benefits of collaboration, as well as the challenges, may be somewhat different for industry partners….Many collaborations do not fulfil expectations and some have been major disappointments" (Mann, 1996; cited in Cripps et al., 1999:22). These views have been echoed in other studies (e.g. Turpin et al., 1993, Cyert and Goodman, 1997) that capture the many negative stereotypes held by the respective partners in cross-sector collaborations. Typically, industry complains about their research relationships with universities as being "…risk-prone, long-term oriented and insensitive to industry needs" (Lee and Gaertner, 1994: 395) or too strict and rigid with IP and the use of staff time (Feldman et al., 2002: 109; Rappert et al., 1999: 888). By the same token, researchers who have interacted with industry complain about "…threats to the free flow of ideas and research results, industry's unwillingness to take risks and frequent interest in 'quick-fix problems', and industry's interest often in short-term rather than long-term research" (Harman, 2001: 253). Each sees risks in partnering and these are more than calculated risks.

Perceived risks play a large part in shaping UIPs and the trust dynamics that develop over time, including the lack of trust. Subjective estimates about a potential loss or negative outcome (i.e. "downside risk") in a given partnership are critical to the types of commitments parties are prepared to make to a venture (Das and Teng, 2001: 251-4). Risk is a multi-faceted concept that entails two major types: performance and relational risks (also see Das and Teng, 2001; Das and Teng, 1999). Drawing on the literature and our initial case study research, a typology of risk, as shown in *Figure 2*, has been developed.

Venture Specific Risks

Environmental sources of risk to a venture have already been mentioned and include: government policy changes, fluctuations within national and global economies, changes in markets, structural changes in relevant industries and changes in the level of competition, and the pre-empting of a venture's goals by a competitor. Today we would have to include terrorist threats in some parts of the world (James, 2002). These sources of risk occur in the environment (macro and industry environments) that is external to the venture and its collaborating partners, and as such, are outside the direct control of the venture partners. "Sheer bad luck" could be a term that is applicable to the occurrence of some of these possible events.

Figure 2 – A Typology of Risk Sources in Interorganizational Collaborations



Adapted from: Couchman and Fulop (2001)

Performance risks arise from the venture's goals, organization, management and resources, and do not result from any opportunistic intentions of the parties or from external events. These risks are a particular problem for collaborations which involve difficult or novel ventures such as R&D projects (Ring and Van de Ven, 1989) and arise from the perceived *uncertainties* associated with the collaborative venture being able to accomplish its tasks and achieve its goals despite the best efforts of the partners. Such uncertainties arise either from the environment or from within the venture itself. An initial listing of internal sources of risk would include the following:

- *scientific-technological* (required knowledge may not be produced or a technology created might fail or under perform),
- *product-related* (the product might not meet required performance standards or may be a cause of hazards and therefore subject to product liability),
- *competence-based* (the venture may lack competencies in areas critical to its success),
- *process-related* (critical internal and interorganizational processes, such as lateral communication, may not develop),

- *resource-related* (this may arise from the unavailability of appropriate human and technical resources),
- *financial* (budgets might not be adequate or appropriate or are poorly managed), and
- *contingency* (these arise from a lack of time, information or control over the venture).

Risks associated with the performance of the venture are shared by all of the partners. Indeed, this is a major motivation for organizations to enter into strategic alliances to pursue particular goals:

> … performance risk is part of every strategic decision, because performance can always fall below one's expectations. Whereas relational risk is created and is present only in alliances, performance risk relating to any undertaking is something that is shared by all partner firms. For instance, joint bidding enables partner firms to share the costs as well as the performance risk involved in a contract. Rather than pursue projects alone, firms use strategic alliances to reduce their performance risk (Das and Teng, 1999: 53).

However, in cross-sector collaborations, the clashes of cultures mean that performance risks are even more difficult to manage. For example, it has been noted that firms often seek additional commitments from scientists to ensure that research work is undertaken in a timely manner to avoid losses, such as delays in getting patents registered (Liebeskind and Oliver (1998: 129). These commitments are deemed essential to ensuring that the firm is not beaten to market by competitors or wastes money on unpromising avenues of inquiry. Firms are constantly worried that researchers will be distracted by "interesting problems" or other project demands that can potentially harm a partnership (see Kreiner and Schultz, 1993; Liebeskind and Oliver, 1998).

Our own research on CRCs is specifically investigating how performance-related risks are managed across a range of project-types. It has been generally observed that:

> Firms typically do not understand how work gets allocated in universities or how university budgets are created, nor are they familiar with the investments in human and physical capital that preceded their relationship with the university. University partners typically do not understand market forces, time demands, and the incentive structure of the firm (Cyert and Goodman, 1997: 48).

Relational Risks

Relational risks include: the possibility of one partner opportunistically exploiting other partners to its own advantage (e.g. by breaking confidentiality agreements; misappropriating proprietary knowledge to engage in unexpected competition; appropriating all or a disproportionate share of benefits, etc.); a partner not fully committing to the venture (e.g. by not providing agreed resources or information; economizing on top management attention; harbouring hidden agendas; delivering unsatisfactory products and services); spillovers (i.e. through collaborative relationships a company's strategic knowledge and core competencies are leaked to competitors); and cheating and misleading others (Das and Teng, 2001: 253-254).

Another approach to the problem of relational risks points to the "vulnerability costs" that organizations need to prepare for as "…a premium for the risk involved in joining the collaboration" (Genefke, 2000: 1). These costs can be identified in terms of two dimensions: (a) structural dependence and (b) information asymmetry. Structural dependence occurs when, for example, a research partner is used for a long period of time and the firm becomes dependent on this supplier because the firm has failed to develop the research capability in-house to do the research on its own. Hence, they become a hostage to all the external events that affect the research partner, including unreasonable demands (Tapon and Thong, 1999: 229). Information asymmetries arise when one of the partners has less information than the other(s) about the collaborative venture and hence "… the greater the possibility for making mistakes, and the greater the potential for being cheated" (Genefke, 2000: 4). Conditions of "information dominance", where one partner has more information than the other, so creating a relationship of dependence, can prove problematic for the partner with the lesser information. The latter is vulnerable because there is every possibility of being cheated on, squeezed for unnecessary resources or even having things stolen from them (e.g. trade secrets) by the dominant partner (Genefke, 2000: 4).

To Trust or Not to Trust?

The IOC literature has emphasized the importance of building mutual trust to the success of IOCs in which relational continuity is important, such as in R&D projects or ventures that can run several years (e.g. Powell, 1990; Ring and Van de Ven, 1992, 1994; de Laat 1997; Ring and Van de Ven, 1989; Häusler et al., 1994). As Macdonald et al. (1999: 5 - 6) have put it:

> (Trust) is required to compensate for the deficiency inherent in formal agreements – basically that, no matter how carefully they are compiled, they cannot cover every eventuality. So, an unwritten agreement accompanies every collaboration, by which all parties understand what else is required of them beyond the formal terms of collaboration. While a collaboration may be established instantly, the trust, which underlies the success of the collaboration, cannot.

In other words, where two or more parties trust each other, they accept the risk that the others may not behave as expected or agreed; this is the risk that the trust may be misplaced. For some, trust always carries the probability of risk of betrayal (Nooteboom, 1999) or simply being a façade of trust, where one can be fooled into trusting another (Hardy et al., 1996). Trust is a slippery concept, but generally entails positive outcomes that can reduce risks without having to do anything about a partner (Tapon and Thong, 1999: 227; Das and Teng, 2001: 254). It is commonly accepted that in R&D partnerships, trust encourages risk taking and the sharing of proprietary information as well as countering the problems of having to introduce excessive controls into what is largely an unpredictable and uncertain area of activity. Excessive controls, such as contracts, can create distrust or even spiralling distrust where the game becomes one finding ways to breach a contract (de Laat, 1997). Trust dynamics in IOCs are built on two forms of trust - in fact not really trust but rather, trusting, which is based on an expectation of something positive (Das and Teng, 2001: 255).

Goodwill trust is a resilient form of trust associated with having perceived personal qualities that one can depend on, such as: being equitable, fair in one's dealings, high in integrity and standards of conduct, high in reciprocity, able to keep confidences, and being selfless (Ring 1996, cited in Das and Teng, 2001: 255; Fulop and Couchman, 2000, 2001). Goodwill trust builds up over time and develops through successful repeat encounters and if sufficiently strong can lead to “hand-shake” agreements. Those firms that develop skills in managing research partnerships can use the trust dynamic as one of their competitive advantages, especially if the basis of the relationship is built on goodwill trust that is exceedingly difficult for others to develop (Tapon and Thong, 1999: 227).

Competence trust is associated with more fragile and calculative forms of behaviour and is focused on such things as expertise, know-how, and the ability and capacity to do certain things, as distinct from the intentions of doing them. Organizations and individuals can build reputations based on competence trust and, in some circumstances, the reputation of a partner precedes them and can be a catalyst for forming an alliance (de Laat, (1997; also Das and Teng, 2001). This does not mean that goodwill trust will develop. The reputation of a collaborating partner can help attenuate fears of opportunism and encourage risk-taking behaviour, and over time resilient trust might or might not develop (Ring, 1992; de Laat, 1997).

Erosion of Trust

The pattern in pre-commercialization research in the past has meant that for private sector partners, performance and relational risks were relatively small in probability and impact. Relational risk, and particularly opportunism, is much less of a problem with less market-driven partners and projects. Given their past history of being non-profit focused, as well as their missions and modes of operation, public sector organizations are far less likely to engage in calculated strategies and opportunistic behaviour, such as free-riding, capturing a disproportionate share of the benefits, or appropriating and exploiting proprietary knowledge of the other partners. University researchers have not been in the past seen as major financial beneficiaries of R&D and are still not in many cases in Australia (Harman, 2001: 259). In fact, a study of federal laboratories in the US found that one reason for research joint venture partners inviting a federal agency to join was its perceived role as an “honest broker”. This role was seen as helping to reduce various monitoring and transaction costs associated with the potential opportunism of private sector firms (Leyden and Link, 1999: 581).

Commercialization will alter relationships and expectations on both sides. In common with each other, large and small businesses seek complementary research activity with universities such as access to personnel, facilities and government funds (Hagedoorn, et al., 2000; also EIRMA, 1995; Rappert, et al., 1999; Tidd et al., 2002). It is clear that large and small firms also have different capabilities in absorbing the additional costs and time associated with formal contracting that inevitably arises with IP and licensing. Large organizations often see their relationship developing on the basis of “information gifts” being part of the university’s commercial courtship ritual to get them on board (Zechhauser, 1996, cited in Hagedoorn, 2000: 575). Once they are onboard in R&D, large organizations will usually want significant control over IP with the resources to commit to secure such an outcome. Small and medium-size enterprises are, with the exception of areas associated with break through technologies, not in the game of IP rights protection or enforcement, and are most likely to be the ones turned off partnering with universities in the licensing and IP game (Rappert et al., 1999: 884; Shane, 2002b).

Industry has various ways of dealing with IP and relational risks by developing various forms of credible commitments or ways of arranging partnerships so that violations affect all members (de Laat, 1997). Joint-equity has been one of them, and in the evolution of university commercialization, similar arrangements are emerging (Gome, 2002). Nonetheless, the focus on IP protection will remain in many areas of R&D and will involve excessive focus on controls and performance risks. Our own research on CRCs provides evidence of this, particularly the tensions and strains that emerge over different types of research projects, some not so commercially sensitive and imbued with goodwill trust, and others more fragile and absorbed by IP conflicts (Couchman, Fulop, and Batchelor, 2002).

Industry quite often has a different view of IP, regarding the substantial background knowledge of a university as evidence of competence to enter a collaborative venture, but of no higher value than the other kinds of background knowledge that the industry participants bring to the table. In reality, both parties need to bring their knowledge to the collaboration in such a way that it can be shared and enhanced. However, note that most firms believe in the "golden rule" – if we pay the gold, we make the rules. Some universities have standard forms of agreement aimed at protecting their background IP, and making new knowledge from a collaborative venture available for teaching (some government research organizations have similar views). A common outcome is that, even when the parties have jointly won a government grant for a new program, formulating a contractual agreement can take a very long time, or the program may be abandoned when agreement cannot be reached. Another outcome can be that, whilst some form of agreement is indeed reached, it may be unworkable, making knowledge from the collaboration unusable in practical terms.

Collaborating companies also face risks associated with the performance of the venture, but the resource commitments made are generally much smaller and more manageable than for in-house development or joint ventures with other companies (see previous discussion). In other words, the costs of failure or under performance of a cross-sector venture are not high for the collaborating companies, at least not the larger ones, and are often greatly outweighed by the potential benefits.

While the main benefit of R&D collaboration for the public sector organizations is access to extra funding to support for their research activities, it does expose them to a range of risks. Public sector organizations are certainly susceptible to relational risks (e.g. a collaborating company may misuse knowledge brought into the venture or may appropriate a disproportionate share of the benefits produced), as well as to the performance risks of the venture itself (which may fail to deliver on its objectives). However, there are different risks for public sector organizations over and above those faced by all collaborating organizations.

Cross-sector collaborations can significantly alter the trust dynamics that underpin research and innovation. Whether it is referred to as a "barter economy" of science (Robertson et al. 1997) or the "social capital of scientific credibility" (Leibeskind and Oliver, 1998: 123), the inference is the same. Scientific communities develop their knowledge base and their potential to innovate from networking both formally and informally. This networking involves the sharing of privileged and proprietary knowledge, the swapping of crucial and unpublished information on research findings of others, exchanging current thinking and wisdom on pressing problems, and foreshadowing future areas of research (Tapon and Thong, 1999: 224, quoting Kreiner and Schultz, 1993). Confidentiality argreements, IP and other constraints of commercialization can undermine scientific credibility because of the secrecy and exclusivity surrounding the research findings in UIPs. Studies in the US and here (Leibeskind and Oliver, 1998, Harman, 2001; Couchman, Fulop and Batchelor, 2002) confirm this trend.

REPUTATION RISKS AND INSTITUTIONAL TRUST

Another major risk faced by public sector organizations is that of a dilution (or even a contradiction) of their "public good" role and ultimately the reputation of the university. For public sector research agencies, this is typically a requirement under establishing legislation to carry out research "in the national interest" in order to pursue national socio-economic objectives. For universities, this role is to provide education and training (thereby creating human and intellectual capital, and making universities "the core institutions of the knowledge sector"), and to generate and disseminate knowledge as a "public good". The public good characteristics of such knowledge have long been recognized in economic theory (e.g. Arrow, 1962) and include: it is not depleted when shared, once it is made public others cannot easily be excluded from using it, and it can be made available to a number of users simultaneously at no extra cost to the producer. Economic theory holds that markets provide poor incentives for the production of public goods because the producers cannot appropriate the economic benefits (i.e. producers cannot recover the costs of producing the good from those that benefit). This "market failure" is often cited to account for the propensity of the private sector to under invest in R&D and to justify government intervention.

The trend for public sector organizations to become increasingly involved in collaborative ventures that are oriented towards commercialization (in a zero sum game, this means fewer resources can be devoted to "public good" research and even basic research) has a number of significant implications. In the first place, it has implications for the institutional rules and conventions under which research takes place (Dasgupta and David, 1994). A number of researchers have already identified fundamental changes in contemporary science and technology. Ziman (1994) has described the changes as a "radical, irreversible, world-wide transformation in the way science is organized and performed." Gibbons et al. (1994) have postulated the emergence of a "new mode of knowledge production" ("Mode 2") in which scientific research is carried out more in a context of application (rather than being focused on problems of interest to a scientific community), and which is more heterogeneous and transient in its organizational forms (as opposed to the hierarchical and discipline-based nature of conventional science). A key question here is: could this trend undermine the reputation-based reward system for researchers that as some theorists have argued (e.g. Dasgupta and David, 1994), ensures that a socially-optimal level of reliable knowledge is produced? If it does so, then this could be a case of "killing the goose that lays the golden egg", e.g., by reducing the potential for serendipitous discoveries by curiosity-driven researchers (arguably less likely to result from research which is application-driven).

The implications of commercializing university R&D, or making it more commercially focused are, in fact, far sweeping. As universities have come to interact more with industry, the character of research has been changing, with figures showing that investment in basic research in US universities had fallen from 77% to 64% over a twenty year period, with the majority of the decline occurring in the early 1990s (Cohen and Noll, 1994: 61). Commercialization is usually accompanied by a greater focus amongst certain researchers on applied problems and research questions that will yield patentable outcomes, faculties substituting discovery research for more commercially oriented post-discovery research projects, and universities deliberately using new commercial opportunities, such as equity holdings, to channel knowledge into privatized forms (Feller, 1990: 343; see Thursby and Thursby, 2002 for a slightly different view).

A second major implication is the possibility of international cross-sector collaborations undermining the "national interest" role of public sector agencies, e.g., by creating or transferring intellectual property to overseas companies and thereby causing economic disadvantage to local companies. In Australia, such risks have indeed been recognized by CSIRO when, in 2000, its Board reviewed its international activity policy framework (CSIRO, 2000):

> "….while the framework offers various benefits to both CSIRO and its industry partners, it also carries some risks that must managed. These include:
>
> - assisting competitors of Australian industries;
> - technology leakage;
> - dilution of Australian-based research effort;
> - diversion from strategic focus;
> - risk exposure due to limited Divisional commercial skill and experience in the international arena;
> - company ownership and consequent benefit flow-on issues;
> - compromised return to Australian taxpayer;
> - political risks of accepting or rejecting international work."

However, while these risks have been recognized and documented by CSIRO's Board, there is neither evidence yet of any diminishing of the organization's enthusiasm for this type of collaborative activity, nor indeed of the necessity to pursue such arrangements to maintain levels of external funding.

A third implication is that through the increasing focus on commercialization, research activities in universities are drawn more and more towards market ends, and they are becoming more driven by a concern to protect research products (and even teaching products) as "intellectual property". This formal granting of property rights enables researchers to retain control over their products (i.e. by providing the legal means to deal with unauthorized usage of this property), and it provides the potential to derive economic benefits over a defined period of time from this property. This approach, and the associated issues of maintaining secrecy with respect to what becomes proprietary knowledge (e.g. it is important in patenting to establish the claim of novelty), is quite at odds with the traditional approach of academic research with its orientation towards research outcomes as a "public good" as discussed above. Indeed, the notion of "intellectual property" as a commodity, traded like other commodities in markets, is the very antithesis of scholarly endeavour. In a university environment, much research is driven by curiosity and the interests of a scholarly community, with little consideration for market opportunities (although under fiscal pressures, this may well be changing).

Fourth, increasingly we are asked to trust in institutions as more impersonal forms of trust-based relations permeate our lives and intercede where once personal or professional relations were important (Zucker, 1986; Pixley, 1999; Bachmann, 2001). Yet everyday our faith in certain institutions is eroded or betrayed. Institutions are critical to creating norms and values that can encourage trust in them and in the people who work for them. Universities have "…accumulated intellectual and political capital not only because of their scientific and technical expertise, but because of their symbolic and putative role as …social institutions whose individual members are available to serve as 'neutral' sources of expertise" (Feller, 1990: 346). Motives of private gain, as Bok thought, would diminish trust in academics by their colleagues and secure "…unmixed admiration of the public" (Feller, 1990: 346-7).

However, it does not end there. As consumers become increasingly mobilized to take class actions for the damages wrought by pharmaceutical and tobacco companies, to a name but a few, it is likely universities will also be included. Only this year Oklahoma University has found itself facing a class action over breaches in regulations relating to clinical trials involving an experimental drug (Lemonick and Goldstein, 2002). The scientist involved had links to a pharmaceutical company, but in essence it was not this link *per se* that seemed to cause the serious breach of ethical standards, but the connection was nonetheless made by *Time* magazine. Similarly, in another major scandal involving clinical trials at the University of Pennsylvania in 1999, the principal investigator and the university owned equity in the company that owned the rights to license the drug the researcher was studying, raising serious concerns about conflicts of interest (Lemonick and Goldstein, 2002: 50-1).

CONCLUSION

It is a bit difficult to find examples of useful lessons universities might learn from each other about commercialization. I have only found a couple to date, and these were extrapolated from a failed effort at commercialization at the University of California in the 1990s (Matkin, 1994) and a more successful one at Iowa State University (Lee and Gaertner, 1994). Principally, drawing on the University of California experience, the first lesson that could be learnt is that conflicts of interest have to expected and be prepared for with review committees, scientific panels, strict guidelines and other buffering mechanisms put in place, as well as public relations strategies to manage these transitions. Oklahoma's problem mentioned above arose from the failure of its ethics committee to do its job and it is by no means the only university with this problem. Commercialization brings very different challenges and demands from those of normal research.

The second major lesson relates to developing a policy agenda that precedes major events dealing with commercialization. Policies developed on the run, and in response to crises, are unlikely to smooth the road to commercialization. Administrative support has to be built up and hurried processes of consultation avoided at all costs. An important lesson is that the commercialization policy has to involve extensive consultation and opportunities for ongoing feedback from the wider university community. Providing forums for debate for new and emerging issues have to be incorporated into commercialization protocols and be an ongoing feature of the process. Universities should look far and wide, and not to one university only, for models of commercialization, and always with the view to seeking alternatives.

The guiding principle set down for commercialization and UIPs should emphasize the good to society, and make a commitment that the best mechanisms for economic development of each technology will be sought, even if this means the university does not maximize its financial return. There is even the suggestion that university sponsored commercialization should only be considered after the technology has been marketed (Matkin, 1994).

Choosing partners carefully and creating a pool of commercial developers will help avoid issues of conflicts of interest and avoid future scandals. The reputations, capabilities of potential partners should always be of paramount importance. External sources of funding must be sought in order not to put at risk other important roles the university must fulfil (also Lee and Gaertner, 1994). In employing professionals to progress commercialization and UIPs, there must be oversight mechanisms put in place to ensure that these people do not act against the university's interests through frustrations with rules, regulations and policies, and a lack of understanding of the diversity of cultures within a university. Autonomy and restrictions are important in the buffer organizations created for commercialization. As one study in the US found in relation to university equity ventures and technology transfer officers, these experts bring their own regimes of risk taking behaviour that need to be carefully managed (Feldman et al., 2002).

The commercialization policy must be integrated with all relevant policies affecting private consultancy, leave, promotion, conflicts of interest, graduate employment and career planning in general. From our own research, I would add training of staff in such areas as project and risk management as well as some general business principles. Scientists employing managers to run their ventures still need to manage these professionals. Last but not least, transparency in financial reporting should be aimed for and be a part of the culture of commercialization.

Companies engage in various forms of risk shifting to public organizations, which ensures that their exposure *qua* their partners is properly managed on a risk and return basis. Public agencies, such as universities in Australia, are not geared to these forms of risk management or assessment. Cross-sector collaboration is a high-risk strategy if the *status quo* is to be defended and an equally high-risk one if change is being sought. To change the universities by stealth and incremental forms of collaboration and policy adjustment is tantamount to "death by a thousand cuts". The social capital of universities cannot be transformed so easily as might occur in other forms of collaboration. Indeed, most studies that have examined this aspect remain pessimistic and skeptical about how much can be achieved in terms of knowledge generation and risk taking once commercialization intercedes in traditional R&D relationships. Commericalization needs to be developed in a comprehensive approach that accepts a complex view of managing of risks, even down to project risks. This won't be easy because there is still much to learn about UIPs and commercialization but we have to start somewhere. Otherwise, when crises or setbacks occur, these will be seen as "…isolated instances of bad judgement or bad luck, calling for ad hoc solutions" (Matkin, 1994: 383).

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