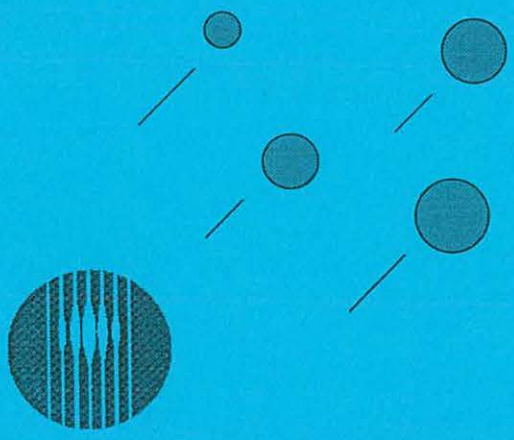
Technology Transfer Through Spinoff Companies:

CSIRO - 1985 to 1995



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Foreword

CSIRO has an important role in transferring the benefits of its research to assist Australian industry. It does this in a number of ways including collaborative and contract research and licensing technologies. The subject of this working paper, the generation of spin-off companies, is another way technology may be transferred from research organisations and academic institutions but one which has received little study in Australia to date.

This paper has been commissioned to better understand the creation of spin-offs from CSIRO, and the Organisation's record relative to comparable institutions overseas. A better understanding of the recent experience of these companies will assist future policy development in relation to spin-offs.

It reveals a significant number of companies that have been established by CSIRO staff who have based their enterprise primarily on knowledge developed within CSIRO projects. Further, these companies have been more successful than might be expected from general patterns here and overseas.

This study provides insights to enable the Organisation to reflect on, and to review, both its policy and practice in ways that will increasingly facilitate this form of technology transfer.

In addition, I believe that the study has broader implications of relevance to a number of other organisations.

C M Adam
Deputy Chief Executive, CSIRO

Technology Transfer Through Spinoff Companies: CSIRO - 1985 to 1995

Executive summary

In some countries, notably the US and the UK, considerable attention is focussed on new companies founded by individuals who leave universities or other research institutions to commercialise research done in those organisations. Such companies are labelled "spinoff companies". Much of the overseas research focuses on claims of benefits flowing from the formation of spinoff companies, including net economic impact and employment generation.

By contrast, there has been little information published regarding the number and health of such companies in Australia, or to the factors and processes involved in their development. This paper reports research designed to address this deficit. It documents a study of spinoff companies formed from CSIRO between 1985 and 1995. This period was chosen primarily because of the reliability of data available.

Forty two spinoff companies were identified from internal data. The following information was gathered for this set of companies:

- the scope of the research program which led to the spinoff;
- the commercialisation process and rationale for choosing a spinoff company as the most appropriate technology transfer mechanism;
- the chronology of events leading to the company's formation;
- the personnel and intellectual property arrangements on establishment;
- any additional assistance (eg. laboratory or office space, or research assistance) provided by CSIRO;
- indications of any continuing interaction between CSIRO and the company;
- current turnover and staff (where available).

This report summarises the findings, draws some conclusions, and provides brief case studies of some successful spinoffs. The study revealed that CSIRO has produced 42 spinoff companies since 1985, an average of 1.3 per year for every US$100m of R&D funding provided to CSIRO by the Government (appropriation funding). This rate of new company formation compares favourably with that of the larger US institutions which are well-known for spinoff creation. The typical CSIRO spinoff company is relatively small, is in the manufacturing sector (although not all are manufacturers), and is in Sydney or Melbourne. This is in line with European experience - small, solid companies which enable technology to move into industry, but which rarely develop into global high fliers. Sometimes, however, the spinoff companies have developed links into other sectors of the Australian economy and may be providing support to some very large companies. This could be fruitfully analysed in further research on these linkages, and the contribution of CSIRO's spinoffs to business enterprise R&D in Australia.

Technology Transfer Through Spinoff Companies: CSIRO - 1985 to 1995

Introduction

The formation of spinoff companies from universities and research institutions in Australia has received only passing attention as a mechanism of technology transfer. By contrast, in the US, Sweden and the UK there have been several studies of such companies' contribution to technology transfer, local and regional economic growth, and employment. Many of these studies concern universities, which have missions and operating constraints very different from those found in research institutions, particularly government funded research laboratories. Nevertheless, for the purpose of this study it was felt that the process of commercialising research and technology is sufficiently similar to make comparisons useful.

"Spinoff companies", in this context, are those formed by personnel who leave their university or research institution to set up an independent company which will commercialise some aspects of the institution's research. Definitions of spinoff companies vary, but for this study a company was included only if a researcher left CSIRO and there was formal technology transfer from CSIRO to the new company. Spinoffs therefore start small and are based upon ownership of some piece of intellectual property. In most overseas cases studied, the source institution also takes equity in the company, as a way of providing input into the technology development.

Claimed benefits of spinoff companies

Studies of spinoffs from the US university, Massachusetts Institute of Technology (MIT), suggest that spinoffs contributed US$10b annually and 300,000 jobs to the Massachusetts economy (Roberts & Malone, 1996), while spinoffs from the University of Cambridge are claimed to contribute over 14,000 jobs and £890m per annum to the local economy (Segal, Quince & Partners, 1985). These figures, however, include "spinoffs of spinoffs" (ie. subsidiaries) which in the Cambridge case inflates the spinoff rate by a factor of five. The US study also includes the vast network of suppliers of goods and services to these high technology companies. The direct impact of the spinoffs themselves in job creation is not clear but is certainly far less, though there have been some well known instances, such as Digital Equipment Corporation (Etzkowitz, 1993) and Dell Computers (Kilcrease, 1995), in which the spinoff companies have become multinationals with significant economic impact.

The rationale for the formation of spinoff companies

There appear to be three main rationales identified in the literature for the formation of spinoffs (Stankiewicz, 1994). These are:

- the technology rationale, where start-ups are a means of transferring technology into the marketplace, often when an appropriate, established licensee cannot be found (Etzkowitz, 1993);

- the institutional rationale, where start-ups are a means of resolving the tensions between academia and an individual who wishes to operate in a more commercial fashion (Stankiewicz, 1994, Samson and Gurdon, 1993; Giannisis *et al*, 1991);

- the profit rationale, where universities start fully or partly-owned companies to retain for the institution the financial rewards from commercialising their technology and control of where and how the technology is applied (Brown, 1985; Roberts and Malone, 1996; Smilor *et al*, 1990).

Despite benefits from spinoff creation enumerated in the literature there is some question as to whether spinoffs are as effective a method of technology transfer for R&D institutions or universities as other methods of transfer, eg. licensing of technology to an established industrial partner (Stankiewicz, 1994). Scientists who start spinoff companies, while being well placed to develop technologies, may not understand aspects of consumer product development and marketing which are critical to successful commercialisation. Further, when transferred into a spinoff company the intellectual property may not be sufficiently developed to result in a product, process or service which can be taken to the market quickly. In some instances the intellectual property may address a general research problem rather than result in a specific product or technology. These are issues scientific research staff may not have the expertise to address.

Promoting spinoff companies

The success of spinoffs overseas appears to be associated with individual institutional policies, rather than an overall government position. Even within any one country there may be significant differences in attitudes to spinoffs, even amongst prominent universities. For example, Stanford University and MIT in the USA and the University of Cambridge in the UK have all had pro-active policies of spinoff creation, while institutions such as Harvard University in the USA and Oxford University in the UK have not.

It would appear from case studies that institutions which promote spinoff formation also tend to have a strong entrepreneurial culture supported by specialised institutional spinoff programs which either provide finance or help companies obtain venture capital. Further, such institutions foster continuing linkages with the institutions, industry and government (Twomey, 1993).

One author claims that those organisations with appropriate policies are generating from 15-35 companies per year (Twomey, 1993) but when "spinoffs of spinoffs" are excluded from the equation 10-15 per annum appears to be the maximum number of spinoffs generated by organisations about which we have information. When the size and budget of the source institution is taken into account, Chalmers University in Sweden appears to have the highest rate world-wide, with 10 spinoffs per year resulting from an R&D budget of US$110m (McQueen & Wallmaker, 1991).

R&D spinoffs in the Australian context

As indicated earlier, little attention has been paid to date to the impact of spinoff formation in Australia: no systematic study of Australian university spinoffs has yet been attempted. It

is believed that the average rate of spinoff creation from Australian universities is low, perhaps less than 15 from the whole higher education sector in 1992 (Twomey, 1993). Even large universities like the University of New South Wales have only two to three spinoffs on their books (Unisearch, 1994).

CSIRO, the Australian Government's largest R&D organisation, aims to translate its research results into profitable industrial products and processes (CSIRO, 1995). It usually licenses its technologies to companies in order to fulfil these technology transfer obligations. The Organisation protects the intellectual property embodied in these technologies though lodging an average of 160 patents per year (CSIRO, 1991).

Interest in spinoffs dates largely from late 1995, prompted by the Australian Government's interest in new technology companies for employment growth. The Government's Innovation Statement, released in December 1995, announced the intention ".....to encourage new companies as business spinoffs from the research sector" (Cook, 1995). This study originated in CSIRO's interest in the value of spinoff creation as a technology transfer mechanism.

Methodology

The study reported here analysed 42 spinoff companies established in the period 1985-1995. In each case an intellectual property agreement provided the basis for the creation of a company by one or more CSIRO staff members.

The study is based on interviews in late 1995 with CSIRO Business Managers located in CSIRO's six main research groups, each of which serves a major Australian industry sector (information technologies, industrial technologies, minerals, environment, animal production and plant production). Business managers are generally responsible for locating appropriate industry partners for CSIRO research divisions, establishing the conditions for effective partnership, and often managing the interaction to ensure CSIRO's research is commercialised for national benefit. These people nominated 62 spinoff companies created since 1971.[1]

Following interviews with Business Managers, the author of this study interviewed people within CSIRO who had been involved in the creation of these 62 companies. These interviews provided most of the material for case studies covering the following issues:

- the scope of the research program which led to the spinoff;

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[1] This group of 62 excludes seven incorporated Co-operative Research Centres (CRCs) in which CSIRO is a minor (or arms length) partner. These CRCs, established since 1991 under a government program which draws from research capabilities in a number of Australian organisations to establish ".... internationally competitive industry sectors through supporting long-term, high quality scientific and technological research" (CRC Program Evaluation Steering Committee, 1995), do deploy CSIRO intellectual property and CSIRO staff. They have, however, normally been set up with a view to undertaking longer term R&D, which probably will be commercialised by licence to the existing partners in the CRC, rather than by establishing new companies. These CRCs therefore do not fit the definition of spinoff companies.

- the commercialisation process and rationale for choosing a spinoff company as the most appropriate technology transfer mechanism;
- the chronology of events leading to the company's formation;
- the personnel and intellectual property arrangements on establishment;
- any additional assistance (eg. laboratory or office space, or research assistance) provided by CSIRO;
- indications of any continuing interaction between CSIRO and the company;
- current turnover and staff (where available).

Details of turnover and staff were checked, where possible, through company searches at the Australian Securities Commission.

As research progressed it became apparent that not all the original 62 companies met the criteria. In some cases data on older established companies were impossible to locate. Twenty companies were subsequently excluded from the sample on the following grounds :

- Four management consultancies, one manufacturing company and one agricultural company had been established by ex-CSIRO staff but no intellectual property agreement had been concluded with CSIRO (although know-how gained while working for CSIRO was used).
- One manufacturing company had not concluded a formal agreement with CSIRO because it used technology related to an expiring CSIRO patent.
- One manufacturing company was excluded because CSIRO had received equity in the company in exchange for contract R&D. No licence agreement had been involved, and no CSIRO staff were employed by the company.
- Twelve companies were set up during and prior to 1984. Details on companies from this period were often sketchy and it is highly likely that the list is incomplete. It was thought that inclusion of an incomplete list would skew the results, so only companies formed during or after 1985 were included.

This procedure left a sample of 42 companies established between 1985-1995 inclusive (see Fig.1).

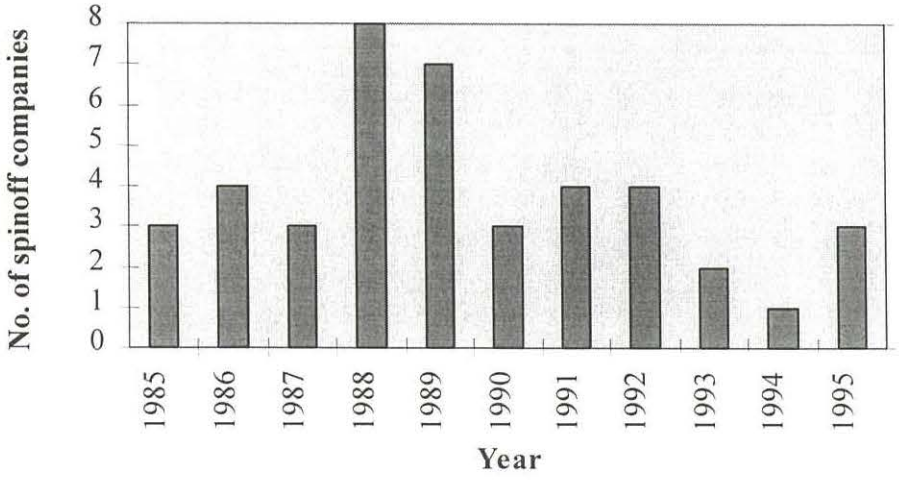

Figure 1: Number of spinoff companies created by CSIRO staff each year from 1985-1995

Results

Rationale for the CSIRO spinoff companies

As described earlier, three rationales have been put forward for the formation of spinoff companies: the technology rationale, the institutional rationale, and the profit rationale.

Table 1 reveals the results of classifying these 42 spinoff companies according to the establishment rationale proposed by interviewees. A fourth category has been added, the market development rationale, to take into account spinoffs which developed in response to an emerging market need. The basis for this categorisation is explained below.

Table 1

Number of spinoff companies in different industry areas classified according to rationale

Rationale	Industrial Technologies	Information Technologies	Minerals & Energy	Animal Production	Plant Production	Environ-ment	Total
Technology	8	6	1	3	3	1	22
Institutional	1	2	8	0	0	0	11
Profit/control	1	0	0	1	1	0	3
Market Development	4	0	0	2	0	0	6
TOTALS	**14**	**8**	**9**	**6**	**4**	**1**	**42**

In some cases where CSIRO has developed technology to an advanced stage it may seek to license this technology to established companies, often after issuing a public request for Expression of Interest (EOI). The EOI is intended to give all potentially interested parties a fair chance of taking up the CSIRO technology. Proposals are analysed for business and technical soundness and a licence fee or royalty is negotiated with the successful bidder.

The technology rationale explains that a start-up company may be created if a suitable existing licensee cannot be found, perhaps because mutually acceptable terms cannot be negotiated, or because of perceived risk in a new market. In the CSIRO sample, 19% of the start-ups (eight companies) arose because of failure of previous joint venture or licensing negotiations; a further 29% (14 companies) established a spinoff following an EOI or an approach to CSIRO. In five of these 14 cases, the CSIRO technology was transferred into a spinoff company which was a subsidiary of an existing company. This was seen to reduce the risk for the parent company.

A substantial proportion of CSIRO spinoffs appear best explained by the institutional rationale. Twenty-eight per cent of the sample (11 companies) were started by staff working in areas of CSIRO where the research priorities were changing. These individuals resigned

from CSIRO or took leave without pay until the new venture was established, and then they resigned. All of these companies were stand-alone ventures, rather than having existing companies as parents. Eight of these cases were from the minerals area. Since they arose over the whole time period it is not immediately clear why those in the institutional rationale should cluster in this sector. Organisational change which occurred at a specific time does not appear to be the impetus for all spinoffs in this category.

The profit rationale is infrequently relevant to spinoffs from CSIRO. Organisational policy (because of its status as a government agency) has limited the number of equity holdings. Thus it appears that only 7.5% of the sample (three companies) were set up and partly owned by CSIRO expressly to keep control of the technology and to create an income. One of these is an R&D company in biotechnology; one is a commercialisation vehicle under a CRC, and the third is a software company. CSIRO constantly monitors its equity position in these companies to ensure its continued involvement is consistent with organisational objectives and risk management strategies. Although profit maximisation is not a dominant rationale for establishing spinoffs, in all 42 cases negotiated licence agreements guarantee CSIRO some financial return as well as meeting the Organisation's technology transfer objectives.

Stankiewicz's rationales therefore account for 36 spinoffs. What drove the formation of the remaining six spinoff companies? All are joint ventures between CSIRO and one or several partners. Joint venture status, in this case, does not imply equity participation, but it does imply an agreement which allows access to intellectual property and joint ownership of R&D carried out by the company. Founders possibly chose to establish companies to develop technology closer to the market than is possible from within CSIRO itself.

In these market development cases the creation of a separate legal entity allows the partner company to take a risk on the new technology without losing its main business if the venture fails. The joint venture structure holds CSIRO committed to supporting the technology over time while receiving returns (royalties) if it succeeds. In some of these cases a separate legal entity enabled access to funding sources unavailable to a research organisation although this appears to have been a minor consideration. Thus these cases are a mixture of the technology and profit/control rationales, driven by a "market pull" philosophy: a wish to ensure that commercialisation was driven by market forces as well as by science (CSIRO, 1995).

Sectoral focus

Previous studies have found that most university spinoff companies cluster in the manufacturing, biotechnology and computing sectors (Stankiewicz, 1994; Samson & Gurdon, 1993; McQueen & Wallmark, 1991; Mustar, 1995; Brown, 1985).

Table 2 shows that the CSIRO spinoffs are predominantly in manufacturing (33 out of 42) which under the Australian Standard Industry Classification (ASIC) includes both biotechnology (if it is for pharmaceutical or food manufacture) and computing software. The CSIRO data also show a significant group of companies working in "services to mining", consulting on issues such as mine safety, mine monitoring and chemical analysis. Four of these seven companies use CSIRO-developed software for this purpose.

Table 2

Distribution of CSIRO spinoff companies by ASIC "industry of product"

ASIC Industry of product field		Number of Companies
Primary industry		2
Mining		0
Manufacturing		33
- food	(3)	
- chemical products	(9)	
- non-metallic minerals	(4)	
- fabricated metals	(1)	
- scientific equipment	(2)	
- electronics/computing	(11)	
- industrial machinery	(3)	
Services to mining		7
Construction		0
TOTAL		**42**

CSIRO also classifies its research by eventual end-user, using 16 socio-economic objective (SEO) codes. Table 3 classifies the 42 companies by SEO code. Using this system, manufacturing is still the major beneficiary (12 companies in 2 categories), with mineral resources and health both coming second (6 companies each), and 5 companies in information/telecommunications. There were three companies working in environmental fields, a result which mirrors experience in France where spinoffs in environmental instrumentation have arisen in the last decade (Mustar, 1995).

Table 3

Distribution of CSIRO spinoff companies by SEO codes and primary activity

Manufacturing	7	5 manufacturers, 2 consultants
Mineral resources	6	2 manufacturers, 4 consultants
Rural based manufacturing	5	3 manufacturers, 2 R&D
Information & communication	5	4 manufacturers, 1 consultant
Health	6	5 manufacturers, 1 R&D
Energy supply	3	2 consultants, 1 R&D
Animal production & processing	2	1 manufacturer, 1 R&D
Environment	2	2 manufacturers
Construction	2	2 manufacturers
Energy resources	1	1 manufacturer
Commercial services	1	1 consultant
Environmental aspects of economic development	1	1 R&D
Transport	1	1 consultant
TOTAL	**42**	**25 manufacturers** **11 consultants** **6 R&D**

Growth and survival of spinoff companies

Thirty-eight of the 42 companies created since 1985 are still operating - a survival rate of 90.5%. However, businesses created recently may still fail. UK and US data show that insolvency peaks between the 2nd and 3rd year of business: from 20-25% of new businesses fail in this period and 60% fail by the 5th year (Storey, 1994; Gourlay, 1995). In Australia the figures indicate greater failure rates: 40% of start-up companies fail in the first two years (Ernst & Young, 1995) with 75% failing by the 5th year (Department of Industry, Science & Technology, 1995). The four CSIRO spinoff companies which ceased operating in the decade each failed after about two years.

The survival rate of the CSIRO spinoffs can be analysed more reliably if we restrict analysis of the data for the five year period 1985-1989 to take account of these trends in company failure. Twenty-five companies were created during this period and 22 of these companies were still operating in 1995 - a survival rate of 88%. Table 4 shows the current standing of this group of 25 companies.

As can be seen from Table 4, ten of the 25 companies remain independent enterprises. Four companies have been taken over by other, larger organisations, presumably after they had established their value in the marketplace. A further two are now listed public companies. Six spinoffs are joint ventures with larger corporations. Of these, five are R&D joint ventures (ie. five of the six in the "market development" group were created in this period), and one was established as a joint venture between CSIRO and a university and was then used for the same purpose under the Co-operative Research Centres (CRC) program when it began in 1991.

Table 4

Status in 1995 of CSIRO spinoff companies from 1985-1989

Start Date	Number established	Number taken over by 1995	Independent	Floated (public)	Joint ventures	Dormant/ failed
1985	3	0	0	2	1	0
1986	4	2	1	0	0	1
1987	3	1	1	0	0	1
1988	8	1	3	0	3	1
1989	7	0	5	0	2	0
TOTAL	**25**	**4**	**10**	**2**	**6**	**3**

Type of Activity

Earlier studies have found that university spinoffs have three main modes of activity (Stankiewicz, 1994), which they may conduct simultaneously.

- Consultancy, R&D contracting, selling problem solving capabilities or specific technical functions: the majority of spinoffs apparently fill this role, and they usually remain small because of their reliance on individual expertise.
- Product development and sales, possibly to niche or limited markets. These companies need to diversify their products in order to grow beyond their initial small size. Relatively few spinoffs are highly successful in this area.
- R&D companies which create, develop and manage technological assets. These companies concentrate on control of intellectual property through patenting but must have appropriate, adequate and complementary assets before they can successfully launch a product. They are often financed by large companies which view them as technological options.

CSIRO's spinoffs may be grouped in these categories as follows:

- 11 of the 42 companies act primarily as consultants.
- 25 of the companies manufacture a specific product.
- 6 companies are primarily R&D companies.

In contrast to what we might expect on the basis of overseas studies, the consulting mode (as main activity) appears to be the least common among the CSIRO sample. This may be due to limitations in the data set (because of the reliance on internal sources of information about these companies). Yet on the surface the data suggest these companies are consistent with overseas examples in that they tend to remain relatively small and they work in niche markets.

The 25 companies which have taken up a licence to manufacture are in the majority. Several of these have gone on to take up further licences from CSIRO or have continued to work with the Organisation on incremental improvement. This has allowed them to overcome some of the limitations on growth demonstrated in overseas studies of such firms. There also appears to be a correlation between the main activity of a company and its startup rationale: 18 of the 22 companies set up for technology reasons are manufacturers. As the company founders themselves have not been interviewed yet, it is not possible to tell whether they fit the individual profile commonly encountered in overseas models of being involved more in development work than in R&D.

The final group comprises the six joint venture R&D companies. These are typical in that they are receiving ongoing support from CSIRO and one or more industrial partners, and they aim to develop products for sale in the short or long term. This classification appears, therefore, to reflect an intermediate step. It is expected that these companies will eventually move into the "product development and sales" category, and will in time become manufacturers in their own right or system integrators.

Despite having a relatively small "consultants" group, many of the companies in the other two categories may also undertake contract R&D for some of their income.

Rate of spinoff formation

As noted early, other studies of spinoffs have claimed high rates of company formation from some research institutions.

It is possible to compare the rate of spinoff formation from institutions by using an index of spinoffs formed per $100m R&D funding developed by Roberts & Malone (1996). Figure 2 compares results for several major research institutions, with CSIRO showing a rate of spinoff creation against R&D investment similar to that of Kings College, London. The data used to calculate the CSIRO average are in Table 5.

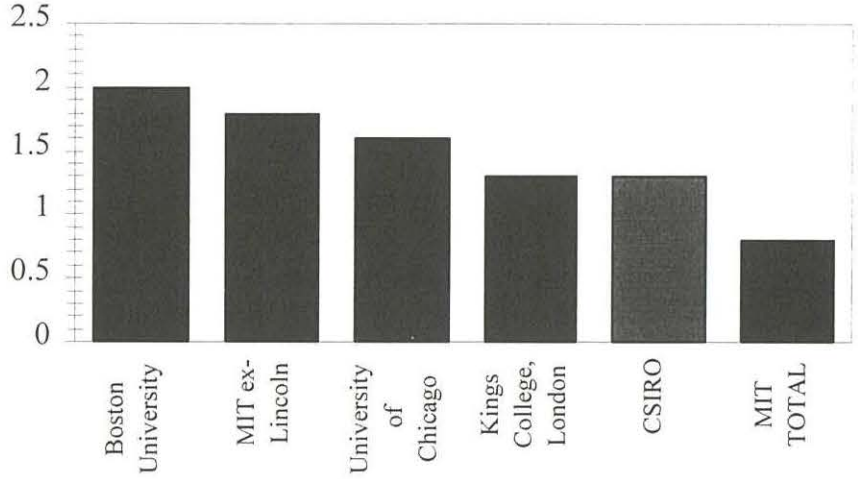

Figure 2 : Rate of spinoff formation per US$100m R&D funding

Source : Robert & Malone, 1996. All universities shown have policies supporting spinoff creation.

Table 5

CSIRO government funding and spinoff formation rates 1985-1995

[source : CSIRO Annual Reports]

Year	Government funding AU$ (Actual) to nearest $1m	Conversion to US$m at year rate	Companies formed	Spinoff rate $US100m
1985	291	189	3	1.6
1986	312	218	4	1.8
1987	330	231	3	1.3
1988	318	222	8	3.6
1989	330	248	7	2.8
1990	363	272	3	1.1
1991	399	307	4	1.3
1992	417	317	4	1.3
1993	415	282	3	1.1
1994	424	292	1	0.4
1995	423	318	3	1.0
Total	**4022**	**3213**	**42**	**1.3**

Contribution of the spinoff companies to employment and economic development

CSIRO has 7000 staff spread over 100 sites around Australia. Even though most spinoff companies are located in Sydney (36%) and Melbourne (23%), the scale of operations and specialised nature of these spinoffs means there is probably less scope for the agglomeration effects evident from the clusters that have grown up around centres such as Cambridge and Boston.

Nevertheless, the impact of these companies is significant. Of the 38 companies still operating at the end of 1995, 29 remain independent Australian companies unsupported by CSIRO funding (ie. excluding three taken over by larger companies, and 6 set up as R&D joint ventures with continued CSIRO support). These 29 companies employ over 270 people (range 1-45) and have a turnover of $60m per annum collectively (range from a few hundred thousand dollars to $25m). If the joint venture R&D companies are included, the figures jump to 400 employees and over $110m turnover.

Overall, figures for CSIRO spinoffs generally reflect the French trends where startups tracked since 1984 have remained sound businesses, with few high fliers (Mustar, 1995). The CSIRO study has revealed:

- a low failure rate of companies (88% still operating compared to 84% in the French study);

- a small number of spinoffs integrated into larger firms so the skills remain in the economy (three out of 38, or 8% of the CSIRO sample, compared to 12% of the French sample);

- moderate job creation (nine people per company, compared to 11 people per company after five years in the French study).

Discussion

Despite the significant record in generating spinoff companies as described earlier, CSIRO has not had a formal, organisation-wide policy to support such ventures. Indeed, its informal policies appear to be quite different from those of the overseas universities which have comparable records in spinoff formation.

Where spinoffs are located off-site, universities sometimes develop venture capital funds to provide capital and take equity in the spinoff company (Roberts & Malone, 1996). CSIRO has eschewed an equity position in spinoffs because of the level of risk and its status as a Government statutory authority. It does not have available Government schemes to support venture capital funds.

Chiefs of particular research divisions appear to have played a major role in providing the environment which nurtures these companies. In at least 14 cases the spinoff company was first located on a CSIRO site or individual staff from the company worked at a CSIRO laboratory. This can foster close working relationships between CSIRO and the spinoff, and presumably allowed some of the tacit knowledge transfer which is now known to be important in innovation (Senker, 1994) to occur. It also supported access to equipment and specialised services (McQueen & Wallmark, 1991).

Chiefs of particular research divisions also have used CSIRO's human resource policies to support spinoffs on a case-by-case basis. In at least 13 cases, CSIRO staff took leave without pay (LWOP) or secondment from their host research division while setting up their company. CSIRO policy permits three periods of 12 months leave without pay, and this fortuitously covers the most risky years for a new venture. If the spinoff fails the scientist can resume his or her career in the Organisation. In the past overseas studies indicated that immediate resignation of the scientist concerned was common. Occasionally scientists worked part-time if the university administration was especially indulgent (Brown, 1985; Samson & Gurdon, 1993; McQueen & Wallmark, 1991). More recently, however, US and UK universities have been offering innovative programs to encourage spinoffs, which include establishing incubator facilities, sharing office space and support functions, and making part-time positions in spinoffs available to faculty (Latrobe University/Finney Whelan, 1995).

The 27 cases in which the company or its staff were located on a CSIRO site and/or staff took leave without pay or secondment relate to 23 companies - so it seems that, at least superficially, the two policies may have been implemented independently. This may be explained by looking at the style of company being established.

- Where the spinoff is set up as an independent company, it is more likely that scientists will use LWOP as an insurance mechanism (eight out of the 13 involving LWOP).

- If a larger partner is involved (either collaboratively or as a parent company), access to CSIRO facilities may be an important issue (eight out of the 14 companies located on CSIRO sites).

- Where the company is an R&D joint venture, secondment of staff is likely together with location on a CSIRO site to ensure access to R&D facilities. This was true for five of the six R&D company spinoffs (there is overlap with the two groups above).

As is the case with many overseas examples (eg. Smilor et al 1990, Mustar 1995, McQueen & Wallmark, 1991), CSIRO's continued involvement with the companies may also have been important. Of the 38 companies still operating, 24 (63%) continue to do joint research and development with CSIRO or subcontract some R&D to CSIRO. Seven companies have subsequently taken up licences of new CSIRO developments. CSIRO maintains "arms length" purchasing contracts with a further 5 spinoff companies, and informal contact with another 3: a total of 32 of the 38 surviving companies (84%).

Future directions

This study has laid the framework for an understanding of spinoff companies within the CSIRO context. It has established that there have been a significant number of companies formed by CSIRO staff as a means of transferring technology to the market and has given some insight into the areas in which these companies are involved. Further, the study has raised a number of important questions which should be addressed. Many of the answers to these questions will require data collection from the spinoff companies and their founders.

From an organisational policy perspective CSIRO needs to know more about the processes which led to the formation of the companies and the extent to which policy and practice within the Organisation facilitated or hindered their progress. The data gathered to date suggest that the autonomy of CSIRO divisions has allowed some to be responsive to staff who have the desire to take personal initiative in commercialising research outcomes. The data indicate also that there has been more of this form of activity in some areas of CSIRO's operations than in others. A more comprehensive picture would enable the Organisation to determine what central policies would create a climate conducive to such activity where it is in the interests of the nation. CSIRO has already begun to gather data which will provide greater insight into this important, but so far little understood, activity.

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Case study - Preschem

Preschem, a wood preservative manufacturer was started out of CSIRO by Chris McEvoy and Chen-Woo Chin. From these humble beginnings it now sells wood remedial treatments to almost every power supplier in Australia, exports to 6 countries and employs 25 people.

Chris McEvoy and Chen-Woo Chin had each worked for more than a decade in the CSIRO Division of Forestry and Forest Products and saw the need for remedial treatment of large structural timber in external environments. Existing products were not completely suited to the requirements of groups such as electricity providers, whose $1,000 hardwood power poles are only at risk of rotting for about a metre of their length.

CSIRO had been approached by some of these users for help and Chris McEvoy and Chen-Woo Chin were convinced of their ability to translate knowledge gained in CSIRO into marketable products. So in May 1989 they decided to resign to do their own R&D and set up Consultants for Science & Industrial Technology Pty Ltd, trading as Preschem. They intended to consult on timber preservation in order to fund their R&D, but found they could not build a business on this.

After 6 months, they decided to manufacture and sell timber finishes and wood preservatives. These provided cash flow (sold in hardware stores), but they still had insufficient funds to collect test data to enable them to get chemicals registered.

CSIRO had agreed to provide toxicity testing and bio-assay facilities under a deferred payment agreement by which Preschem would pay a levy on sales for 5 years once the product was launched. These tests were done between late 1989 and early 1990. This support from CSIRO was crucial in the early stages. Preschem could not have paid for the testing provided by CSIRO, and the royalty arrangement enabled them to defer payment until sales began. In the end, CSIRO received income of $207,000 over 5 years, which was about 15 times the cost of the work done.

The product, "Polesaver Rods", was registered late in 1990 and has international patents. CSIRO also did further testing to provide efficacy data to support marketing. CSIRO data is used in promotional material.

A new Preschem product, Bioguard, was launched in 1993. Bioguard is an incremental innovation, using the same chemicals in a different delivery system, now patented. Preschem now sells its products to every power authority in Australia, except in the ACT.

The company doubled in size every year for the first five years, operating from a factory based in Cheltenham. Now they have 12 staff in Preschem plus 10 in Preschem Pole Maintenance (a contract service company) and 3 interstate sales representatives.

In 1995 their factory burnt down, delaying their export program. They re-commenced the export effort in 1996, targeting Cameroon, Turkey, Papua-New Guinea, Fiji, Europe and South Africa. Presently they have agents in the US and UK.

Case study - Castec

Ho Siauw joined CSIRO in 1975 as an experimental officer with the then Division of Tribophysics. The Division ran a group which researched high pressure diecasting, concentrating on mathematical modeling of molten metal flow.

Between 1972 and 1980 the Division developed software and in 1983 advertised for a collaborator to market the results. The company which became the licensee wanted the software to be developed for mainframes and super mini-computers. Their customers were small automotive suppliers who specialised in high pressure diecasting. Low pressure diecasting was usually done on the shop-floor by larger manufacturers. Ho Siauw worked on the adaptation.

In 1987 Ho Siauw proposed that the Metlfow software be ported to a PC platform.

By 1989 the licencee of Metflow changed focus and decided to concentrate its resources on its own products and not use PC's. As a result CSIRO decided to sell consulting services based on Metlfow direct to the diecasting industry. At this stage the diecasting technology group had four people led by Ho Siauw, who finished porting the software to PC and re-named it DMT CASTFLOW.

By 1992 DMT CASTFLOW was a mature product with 20 users world wide (only five local). Ho Siauw had gained considerable experience in consulting because of the three years spent working with CASTFLOW customers. As a consequence he proposed to take unpaid leave to start a company to consult using CASTFLOW as the basis. He negotiated a licence agreement with CSIRO for exclusive world-wide rights to the software and the ability to develop the software further, with all rights to be assigned after February 1997. By 1993 Castec was formalised.

Castec is a low overhead company and did not need any overdraft to become established. It has grown modestly and steadily since inception. All investment in the company has come from profits.

In 1994 a second employee was added, and Ho Siauw now employs others (electrical engineer, toolmaker) part/time on contract to assist with the development of the next set of software - Castpulse. The Castpulse system collects and monitors casting process variables at the shop-floor. Manufacture of Castpulse will also be contracted out.

Castec has established a network of agents in the USA, Asia, Europe and South American countries. As a result, there are now 60 CASTFLOW and CASTTHERM users worldwide. Roughly 30-35% of income is through consulting or training and the balance is from licence sales. In 1995 Castec received an Export Market Development Grant.

Case Study - ActionLaser

ActionLaser was created to commercialise technology developed within CSIRO for the production of very fine metal screens and sieves used in the sugar industry and elsewhere. Twenty-nine out of Australia's thirty sugar mills now use ActionLaser products, and ActionLaser exports to 20 countries. It employs 16 people, has just opened a second larger factory, and is commissioning a fourth laser system.

Ken Crane, head of Action Laser, led a research program in the CSIRO Division of Manufacturing Technology's lab at Lindfield (Sydney). The Division developed a new and efficient way of using lasers to make very fine industrial metal screens and sieves. CSIRO patented non-centrifugal screens, and jointly held patents with the Bureau of Sugar Experiment Stations (BSES) for centrifugal screens.

In 1987 CSIRO called for expressions of interest in commercialising the technology. Eight companies responded, including ActionLaser, a company formed by Ken Crane. ActionLaser was selected in early 1988, and was granted world-wide rights to the technology as defined by the patent, with a provision that product sales should start within two years.

Both Ken Crane and David Kells, a technical officer with the laser group, resigned in October to operate the company. They employed two other people (including one CSIRO administrator).

At about this time CSIRO had acquired some old buildings adjoining their existing North Ryde site. ActionLaser approached CSIRO to lease some of these at full commercial rates. During 1988, ActionLaser also further refined parts of the laser resonator, and developed a new beam delivery system.

In March 1989 ActionLaser started manufacturing and immediately began exporting. Domestic sales replace imports, since all such screens and filters were previously bought from overseas. ActionLaser boasts over 95% Australian content for all its products.

ActionLaser now has 70% of the Australian market for sugar screens and over $1 million in exports to more than 20 countries worldwide. The company won a NSW New Exporter Award 1993 and a NSW Small Business Award in 1995. It is now expanding its business into screens for other food processing areas, minerals and petrochemicals.

Ken Crane believes that people are an essential part of the technology transfer process.

> *I believe you can't transfer technology without transferring people. You can put as much as you like down on paper but unless you're transferring people you're not transferring technology. You are not giving away successful people. You are utilising them for the maximum.*