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# Engaging with Australian industry: CSIRO in the late twentieth century

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The increased engagement of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) with Australian industry from the early 1980s to the late 1990s marks it as an unusual era for CSIRO. The reasons lie in CSIRO's response to the economic and political background of the time and to government moves to reinvigorate the industrial sector. By the end of the century, external pressures for industry engagement had receded as macroeconomic conditions improved and Australian industry diversified. The engagement can be seen in the growth of direct contacts between CSIRO and research users and Australian companies that occurred across the organisation. This paper analyses CSIRO's technology transfer policies and practices within an economic and political context and addresses two questions: why did the organisation's approach to technology transfer change and how? We look at three mini-eras in the 1980s and 1990s and draw out major changes in technology transfer during these two decades.

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## Introduction

Any analysis of the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) relationship with Australian industry during the 1980s and 1990s needs to be placed in the context of the prevailing political and economic environment. This was an era of increasing interdependence of national economies that accompanied developments such as the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) negotiations, the dissolution of the Soviet Union and opening up of Eastern Europe, the expansion of the European Union and the signing of the Maastricht Treaty. In addition, reforms in China gave it an expanding role in the fast-growing East Asian region. World trade as a proportion of total global Gross Domestic Product (GDP) grew from 38.7% in 1980 to 51.3% in 2000.[1]

By the early 1980s there was growing concern that Australia was not adjusting fast enough to play its part in the changing global economy and the government that was elected in 1983 responded with a rolling program of economic reforms. A major target of these reforms was the reinvigoration of Australian industry and the growth of an internationally competitive manufacturing sector. Technology and innovation were seen as keys to achieving this, leading to new government expectations of CSIRO.

In this paper we look at CSIRO's approach to technology transfer in the 1980s and 1990s and address two questions: why did CSIRO's approach change and how? We apply the term technology transfer to include all the modes by which scientific knowledge generated in a research organisation may be transferred to industry and the market place—ranging from knowledge transfer to spinning off new companies. The paper has been prepared as part of the CSIRO History Project at Swinburne University of Technology and follows an earlier paper on CSIRO's experience in technology transfer during the period 1949–79.[2]

We divide the two decades into three mini-eras—the early 1980s, the mid-1980s to mid-1990s, and the late 1990s—to enable a more finely grained picture. These mini-eras broadly correspond to the terms of CSIRO's chief executives and the governing political parties, as can be seen in Table 1. In the next three sections we address the changing political and social environment in each of these mini-eras and CSIRO's response. Section 5 draws together data on technology transfer practices across the two decades and Section 6 summarizes and discusses the main findings of the paper.

## Early 1980s

### *Economic and political setting*

In 1980, CSIRO continued to dominate the national science and technology landscape as Australia's leading scientific research organisation.[3] It had been established in 1949 'to promote Australia's primary and secondary industries',[4] and succeeded the Council for Scientific and Industrial Research (CSIR) which began in 1926. In the decades of the 1950s and 1960s CSIRO experienced continuing growth and built a reputation for both scientific excellence and economic achievements, notably in support of Australia's primary industries. By the beginning of the 1970s, however, rural exports, notably wool, had slumped and economic growth had slowed. The oil crises that followed were an additional disruptive factor. The 1970s was a decade in which CSIRO's traditional approach, and the centrality of its support for Australia's primary industry, came under question.

[1] World Bank (2018).
[2] Upstill (2019).
[3] Valuable background on this period is provided in Homeshaw (1994).
[4] Commonwealth of Australia (1949).

 

**Table 1. Chairmen/CEOs of CSIRO.**
Executive Head of CSIRO: From 1978–1986 this position was titled CSIRO Chairman. From 1986 on the title was Chief Executive.

| Executive Head of CSIRO | Chairman of CSIRO Board | Minister Responsible for Science |
|---|---|---|
| | | *Coalition* |
| 1978–1985 J. Paul Wild | | 1979–1983 David Thomson |
| | | *Labor* |
| 1985–1990 N. Keith Boardman | 1986–1991 Neville Wran | 1983–1990 Barry Jones |
| 1990–1995 John Stocker | 1991–1996 Adrienne Clarke | 1990–1991 Simon Crean |
| | | 1991–1993 Ross Free |
| | | 1993–1994 Chris Schacht |
| 1995–1996 Roy Green | | 1994–1996 Peter Cook |
| | | *Coalition* |
| 1996–2000 Malcolm McIntosh | 1996–2001 D. Charles Allen | 1996–1998 John Moore* |
| | | 1998–2001 Nick Minchin |

*Peter McGauran, as junior minister, shared responsibility 1996–1997.

In 1977, the government commissioned a review of CSIRO. The Birch Committee Report recommended CSIRO be retained as the nation's principal research organisation but, importantly, that it be reoriented to become more 'applications oriented' and to give 'increased emphasis … to securing implementation of research results through close association with research users'.[5] In the following year the government amended CSIRO's Act in a manner that called for a more active role for CSIRO in the transfer of technology.[6] The first-listed functions in the revised Act were:

**[Para 9(a)]**
- assisting Australian industry;
- furthering the interests of the Australian community;
- contributing to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth.

**[Para 9 (b)]**
- encouraging or facilitating the application or utilisation of the results of such research.

The wording of Para 9(b) indicated a clear intent that technology transfer (although not in those specific words) be a key function for the CSIRO. In this context, technology transfer includes both a linear view and an interactive view (see below).

Australia entered the decade of the 1980s with high levels of inflation and low economic growth. The 1970s had been difficult years for the Australian economy, as Henry has noted:

> The high growth, low inflation and low unemployment of the 1960s encouraged policy complacency. In the benign international environment of the 1960s the costs of an insular, highly regulated policy framework were not apparent. But they became very apparent when the first of two oil price shocks hit in the early 1970s. This was the accident waiting to happen. Inflation and unemployment soared, and certainly by the time the 1970s had come to an end the policy orthodoxy was in tatters.[7]

Unemployment rose to nearly 10 percent during the recession of 1981–3, the highest level since the Great Depression. In addition, there was a chronic balance of trade problem:

> the long-term relative decline of commodity prices (terms of trade) meant that natural resources could no longer be relied on to cover the cost of imports, let alone the long-standing deficits in payments for services etc.[8]

Looking back in 1998, Senator John Button, the federal industry minister from 1983 to 1993 recalled that at the beginning of his ministerial term 'there was a prevailing atmosphere of doom',[9] and that 'Australian manufacturing industry was still focussed on the domestic market. Factories were closing. People were not prepared to think much about longer term solutions'.[10]

It was a challenging environment for CSIRO as it sought to assist Australian industry. The traditional proportionately heavy emphasis on rural-based research was now less warranted. Moreover, the approach that CSIRO had successfully employed for rural industries, which comprised many small businesses and undifferentiated commodities—namely to rely heavily on external state-based extension offices to transfer technology—was ill-suited to manufacturing and other industries.

CSIRO had limited interactions with a manufacturing sector that had grown behind high tariff walls and retained a strong domestic focus. Innovative, exporting firms were hard to find and the demand

[5] Birch (1977).
[6] Commonwealth of Australia (1978).
[7] Henry (2001).
[8] Gillitzer and Kearns (2005).
[9] Emmery (1999).
[10] Button (1998) p. 254.

**Table 2. CSIRO professional staff by sector 1985–86.**

| Sector | Professional. Staff | Sector | Professional Staff |
|---|---|---|---|
| Rural | 737 | Information, Communications & Space | 204 |
| Minerals and Energy | 330 | Construction and Urban Engineering | 59 |
| Natural Resources and Water | 406 | Health | 72 |
| Manufacturing | 621 | Standards, International activities | 92 |

for technological research was low. Indeed business expenditure on research and development (R&D) had fallen to a miserly 0.21% of GDP by 1978/79. As noted in the Birch report:

> The picture is one of firms of small scale, by international standards, with low levels of investment'. and. 'a correspondingly low level of research awareness within manufacturing firms.[11]

*CSIRO and technology transfer (Wild)*

CSIRO was slow to respond to the challenges posed by the Birch report and the deteriorating national economy.[12] In 1982, Dr Paul Wild, a distinguished CSIRO scientist who led the organisation 1978–85, observed that communicating with the manufacturing sector was difficult:

> CSIRO's role of strategic research on problems of wide benefit to an industry requires accurate identification of those problems. This in turn requires close communication with industry, at the 'general' rather than single firm level. Industry has difficulty getting together at this level.

He further noted that the (manufacturing) sector was resistant to innovation as a (rational) response to the environment set by the government's economic and industry policies and that: 'there may be individual successes but the tide is generally against R&D in manufacturing.'[13]

In 1978, following the Birch report, CSIRO was restructured into five institutes that grouped divisions according to national objectives and industry sector. This superseded the organisation's long standing 'flat' divisional structure but, in the event, had limited impact in changing CSIRO governance because the institute directors had minimal executive powers and operated without proper levels of supporting staff. Another change following the Birch report was the gradual rebalancing of CSIRO's research portfolio and shift from the rural sector towards areas such as energy and the environment. Table 2 shows the situation in 1986.

In 1982, the issue of CSIRO's interaction with Australia's manufacturing sector was tackled formally. A committee comprising industry and CSIRO representatives was set up to review the organisation's commercial activities. The Robinson Committee report recommended setting up an Innovation Support Service in CSIRO:

> comprising members of the present Commercial Group, a small team of people with expertise in market and techno-economic analysis, and additional support staff. Professional appointments should be at a sufficiently high level to attract suitable applicants, and the selection panel should include senior people from industry with knowledge in areas such as project evaluation, market assessment, industrial economics and business law.[14]

The report contrasted two views for the transfer of technology to industry. According to the first, the **linear view**: 'technology transfer is an activity best left to specialists (and) CSIRO's role should be to carry out scientific research: development should be left to industry.' The second, the **interactive view**, held that:

> technology transfer is most likely to be successful when the objectives of a research program have been matched closely to industry requirements, and in which technology transfer is an integral part of a research program and is the responsibility of the research scientist and the Chief of the Division.

In this case: 'specialists can play an important role in assisting Divisions with technology transfer, but in a supportive and facilitating way, not as a substitute for Divisional effort.'

The Robinson Committee recommended adoption of the 'interactive view'. Perhaps surprisingly, the CSIRO executive rejected this advice and established a new self-standing technology transfer company, Sirotech, that would report to the executive. This new body began operations in 1984 as CSIRO's principal marketing and patent advisor, responsible for facilitating the transfer of divisional research results to industry, and assisting divisional interaction with industry. (These functions resembled those of technology transfer offices in universities established from the early 1980s in Australia and abroad).

The creation of an intermediary body to promote interaction between scientists and industry was at best only a partial solution for CSIRO. The expansion of commercial interactions with Australian firms at divisional level that occurred during the 1980s meant that Sirotech was to play a dwindling role as the main conduit between CSIRO and industry. Despite some commercial achievements, it was finally wound up in 1993.

## Mid 1980s to mid 1990s

*Economic and political setting*

The election of a new Labor government in 1983 signalled a major shift in economic and industry policy: its objectives included the reinvigoration of Australian industry, and in particular the manufacturing sector. Moreover, it saw technological innovation

[11] Birch (1977) p. 127.
[12] Upstill (2019) p. 7.
[13] Wild (1982).
[14] Robinson (1983).

and R&D investment as the keys to achieving its objectives and expected CSIRO to play its part in the process.

The future directions for CSIRO were the subject of a report by the Australian Science and Technology Council (ASTEC) chaired by Professor Ralph Slatyer in 1985. This had as its first two recommendations that:

- CSIRO's main role be the conduct of applications-oriented research combined with a commitment to ensuring the effective transfer of its research results to users; and
- in undertaking its main role CSIRO concentrate primarily on research in support of existing and emerging industry sectors and measures to facilitate the adoption of the practical results of its research.[15]

In the same year an external review by the Organisation for Economic Co-operation and Development (OECD) of Australia's science and technology policy had observed that:

> the major charges levelled against the Organisation are that its focus is too much orientated to basic research and that it does not pay sufficient attention to technology transfer to Australian industry' (p. 52) and expressed the 'belief that a growing share of CSIRO's budget should be provided in the future by those groups who are to be the beneficiaries of CSIRO's research. These funders should have an increasing role in setting CSIRO's research goals.[16]

In tabling the ASTEC Report in 1985 the prime minister said that the scale of change in the 1980s was such that a redirected role for CSIRO was fundamental to Australia's growth strategies.[17] A similar message was apparent in a speech by the industry minister, Senator John Button:

> Our contemporary and future needs lie not so much in demonstrating our excellence in research, but in adopting a national effort and cooperative approach between scientists and Australian industry. CSIRO has a huge contribution to make in this area. It has in the past made substantial contribution to the success on the agricultural and mining sectors, and will, I hope continue to do so, but it is timely to see a broader emphasis emerging. (CSIRO) has a great responsibility to work creatively in an area critical to the revitalisation of Australia's industrial performance, an area in which we have lagged behind many other countries.[18]

Publicly funded research was an instrument that could contribute to addressing the economic challenges facing Australia and its urgently perceived need to change. One celebrated signpost was the remarks by the federal treasurer in May 1986 when releasing news of the current account deficit, at six percent of GDP the biggest ever recorded in Australia:

> Keating was impatient to get moving on his program of reforms to liberalize the economy, including privatisations and wage decentralisation. Appearing on the John Laws program that day, Keating extemporized that: 'I get the very clear feeling that we must let Australians know truthfully, honestly, earnestly, just what sort of international hole Australia is in. If this government cannot get the adjustment, get manufacturing going again, and keep moderate wage outcomes and a sensible economic policy, then Australia is basically done for. We will just end up being a third-rate economy, a banana republic.[19]

An extended series of economic reforms to promote industrial competitiveness began with the floating of the dollar in 1983, followed by deregulation of the financial sector, reforms affecting manufacturing and service industries, and progressive reduction of tariff barriers. Indeed, by 1991, the treasurer was able to announce that: 'the package of measures introduced today ends forever Australia's sorry association with the tariff as a device for industrial development.'[20]

Australia pursued trade liberalisation internationally through GATT negotiations, the Asia Pacific Economic Cooperation (APEC), and the multinational Cairns Group. At an industry level, industries such as transport and telecommunications were deregulated, several publicly owned corporations were privatized (including the Commonwealth Serum Laboratories that was to become the biotechnology giant CSL). A suite of policies was introduced under Senator John Button to promote manufacturing productivity and efficiency. These included increasing access of local firms to foreign finance and exposing them to greater competition, as well as targeted programs to improve export orientation, technology capacity and growth in the steel, automotive, and textile, clothing and footwear industries.

Measures to promote technology and innovation included the Factor 'f' Scheme for the pharmaceutical industry (1988), tax concessions for venture capital raising by start-up companies (1997), and syndicated R&D (1987–97). Other policy changes included the new prime minister's Science Council (1989) and the Rural Industry R&D Council program (1989) (a competitive funding scheme for rural R&D investment part-funded by industry). In 1989, Professor Ralph Slayer became Australia's first chief scientist and led the introduction of the Co-operative Research Centres (CRC) program in 1990. The goal of this program was to promote greater commercial interaction between public funded science and Australian industry. It was intended, as the prime minister noted:

> to respond to the needs of a wide range of sectors of the economy, as well as to social and environmental needs. The intention of the program is to bring together scientists and engineers of excellence from the Government, academic and private sectors, and so draw together education as well as industry interests.[21]

### *CSIRO and technology transfer (Boardman)*

Dr Keith Boardman, a distinguished CSIRO scientist, and head of the organisation, 1985–90, led the organisation's response to the new economic imperatives of government. The government's intentions were reinforced in 1986 when CSIRO's legislation was again amended, consequent upon the ASTEC report. [22] The revised

[15] ASTEC (1994).
[16] OECD (1985) p. 35.
[17] Cited in Stocker (1990).
[18] CoResearch (1985).
[19] Irvine (2017).
[20] Emmery (1999).
[21] Hawke (1990).
[22] Commonwealth of Australia (1986).

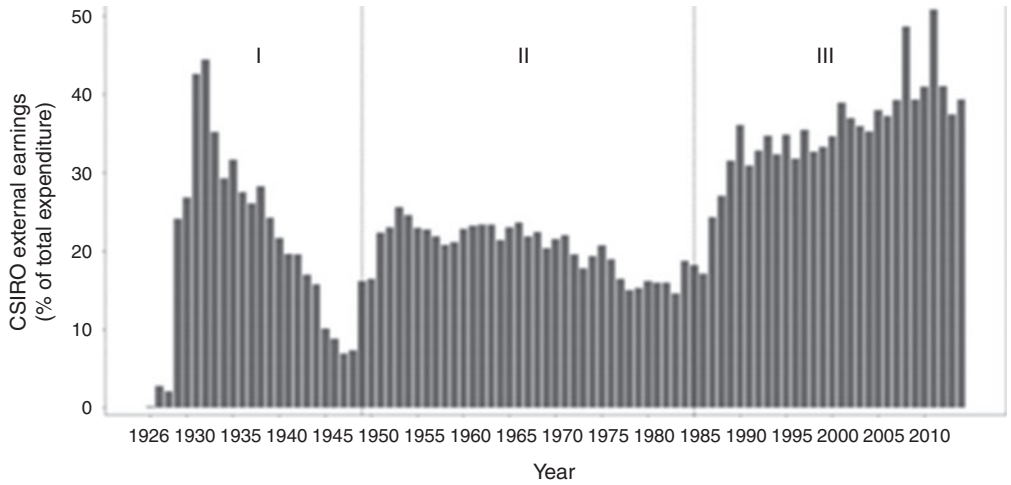


**Figure 1.** CSIRO external earnings as a proportion of total expenditure.

Act made it clear that technology transfer to industry was a primary function of the organisation (specifically that functions set out in paras. 9(a) and 9(b) of the 1978 Act—see above—were of equal standing). The revised Act also established a new governing board for CSIRO and broadened its commercial powers.

These legislative changes were directed, as expressed by the minister for science:

> To help CSIRO place more emphasis on the application of its research, the Organisation is being encouraged to take on more short term problem solving projects, to be paid for largely by the individual companies concerned. An important objective of this is to gain a better knowledge of industries' needs, and to foster mutual respect and confidence. It is not intended that CSIRO substitute for industry performing its own research and development, but rather that it backup and stimulate industry to do more for it.[23]

The new board had its first meeting in December 1986 under the chairmanship of the former New South Wales premier, Neville Wran, and maintained an active oversight role. Two influential reports were commissioned by Dr Boardman from the consulting firm, McKinsey and Co. The first, on assessing commercial prospects for research was to serve as the basis for CSIRO's priority setting framework established a few years later,[24] and the second, on management structures for CSIRO served as the blueprint for a major restructuring of CSIRO in 1987/8.[25] Six new institutes were established (Plant, Animal, Minerals, Manufacturing, Information technology, and Environment) and divisions were modified and clustered within these institutes according to their industry focus. The institute directors had administrative and budgetary powers, and staff with commercialisation, planning and evaluation, and finance and budget responsibilities. External and customer contacts were a shared responsibility for the chief executive, institute directors, division chiefs and research managers.

In 1988, in a move that would have far-reaching effects for CSIRO the minister for science announced an annual external earnings target for CSIRO. The purpose of the target was to encourage CSIRO to improve its links with industry and was set at 30 per cent of total annual income for the triennium (1988–9 to 1990–1).[26] This level of external earnings was considerably higher than the levels of 15–20% prevalent during the previous decade (Fig. 1).[27]

These changes led to a growth of commercial activity in CSIRO and a strengthening of commercial practices.[28] In the 1988 *Annual Report* Dr Boardman observed that: 'over the past few years CSIRO has altered so radically that we have been able to talk of each year as one of profound change, transformation, a year heralding a new era', and that: 'the greater emphasis on commercialisation of successful research, and the improved links with industry, are obvious from the figures.'[29]

The figures showed a more than three-fold increase since 1984/5 in the number of provisional patent applications, commercial opinions and the value of sponsored research. Fig. 2 shows the growth in industry funded research conducted by CSIRO over this period.[30]

### *CSIRO and technology transfer (Stocker)*

In 1990, a new chief executive was appointed. Dr John Stocker, a senior executive in the international pharmaceutical company, Hoffman La Roche, had returned to Australia in 1987 to lead the Victorian government initiated research based pharmaceutical company AMRAD. His work at AMRAD attracted the attention of

[23] Jones (1986).
[24] McKinsey and Company (1987*a*).
[25] McKinsey and Company (1987*b*).
[26] ASTEC (1994).
[27] Lefroy and Porfirio (2017).
[28] CSIRO (1989*b*), CSIRO (1989*c*).
[29] Boardman (1988).
[30] CSIRO (1991*a*).

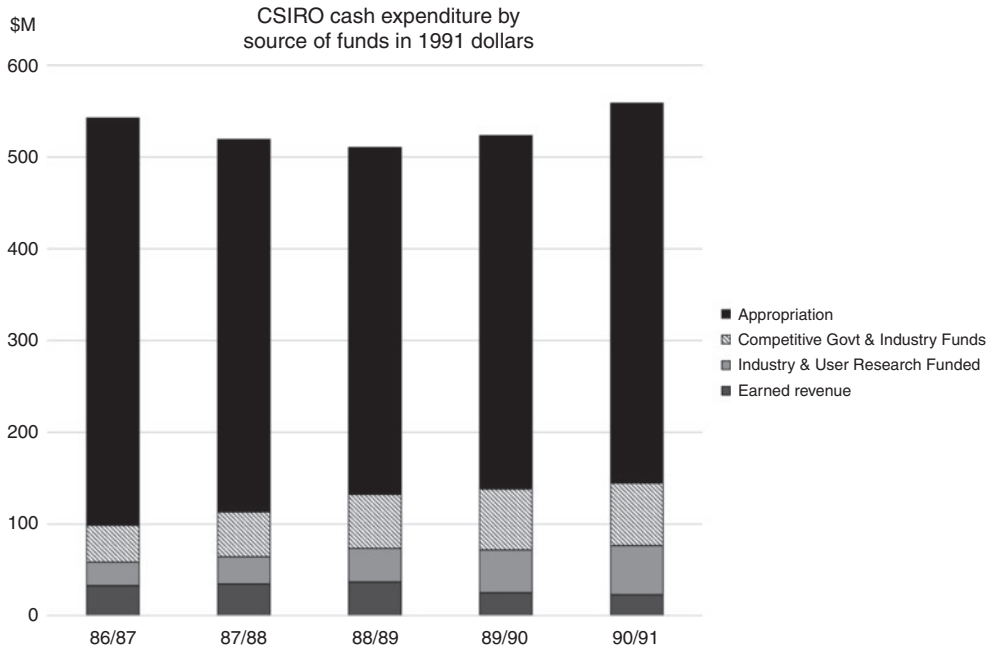


**Figure 2.** CSIRO cash expenditure by source of funds in 1991 dollars.

the new board and he became the first head of CSIRO appointed from outside the organisation. Stocker was charged by the board to bring a new external and commercial focus to CSIRO's research, and to manage the arrangements put in place by the board and the government, aimed at 'creating wealth for Australia through science and technology'.[31] It was a task that faced challenges from the deep-seated operating culture still in place across much of CSIRO.

The first half of the 1990s was a time of substantial change in CSIRO's relationship with Australian industry. Three factors which drove this were the external earnings target, the revised organisational structure and a new triennial research planning regime. Combined, these had a pervasive effect in placing commercial outcomes as a central element in scientists' thinking at all levels of the organisation.

The *30% external earnings target* was a galvanising factor. The responsibility for meeting assigned targets was largely devolved to divisions and through them to program and project level across the organisation. External earnings served as a valuable indicator of the perceived relevance of the research to users in both the private and public sectors. In addition, the *organisational restructuring* linked CSIRO divisional activity directly to industry sectors; moreover, this direct industry focus was strengthened by the institute directors and institute and corporate staff. Finally, a model for setting CSIRO's research priorities introduced under Stocker's leadership provided the framework for CSIRO's *triennial research planning* and budgeting for the 1991, 1994 and 1997 budget triennia.[32] It combined qualitative and quantitative inputs from scientists and industry representatives, prepared according to a public set of protocols. At its heart was an analytical framework that was used to assess and display the 'return to Australia' of different areas of research, based on their 'attractiveness' and 'feasibility', and then to rank them in terms of expected return on research investment, principally through commercial outcomes. Importantly, it was a forum for consultation with research users, and it meant that research activities and user outcomes were explicitly considered in research planning across the organisation.

The CRC program was introduced in 1990. Its aim was to bring together teams from public research organisations, universities and industry to work areas of national importance. The decision on CSIRO's participation in the new program was contentious for CSIRO leadership.[33] On the one hand there were risks for CSIRO in potentially moving key researchers outside direct organisational control and diverting resources from existing research. On the other hand, the program offered the opportunity to engage more fully with companies and other national players. In the event the CSIRO board agreed that:

> the Chief Executive would develop broad principles and guidelines for CSIRO's involvement in the Co-operative Research Centres program which would, inter alia, emphasize the need for proposals to be consistent with CSIRO's objective of increasing its efforts in priority areas currently being determined by the national priorities exercize.[34]

This was a major commitment for collaborative research to advance industry and business development. CSIRO was an

[31] Stocker (1990) p. 31.
[32] Stocker (1990) p. 34; CSIRO (1991*b*).
[33] Spurling and Healy (2017).
[34] CSIRO (1990).

enthusiastic participant in the first round of CRCs and was a member in all but one of the successful applications. In the years that followed it continued to be a member in the majority of the CRCs that were created.

## Mid 1990s to 2000

*Economic and political setting*

Dr Malcolm McIntosh returned to Australia in 1995 from a high-level appointment in the United Kingdom public service to take on the role of chief executive of CSIRO. There was a change of science ministers in the following year, when a new Liberal government came into power (Table 1).

By the mid 1990s, the sense of crisis that had underlain intervention to promote the competitiveness of Australian industry had somewhat eased, reflecting at least in part the success of the microeconomic reforms of the 1980s. The 'inflation stick' had broken and following the 1991 recession Australia entered a long period of uninterrupted economic growth. Annual GDP growth averaged 3.6% in the 1990s, and multi-factor productivity growth averaged 2% in the 1990s, or almost double the average annual rate of the 1980s.[35]

Moreover, worries about the shortcomings of Australian industry had eased. During the 1980s the shares of manufacturing and services in national exports had both grown, reflecting their greater international competitiveness (Fig. 3).[36] There were encouraging signs that home grown internationally focussed technology companies were emerging—as revealed in a 1993 McKinsey report on 'born-global' companies.[37] Services firms, including information communications and technology firms, were playing a bigger role in Australia's participation in the global economy. Private sector R&D was still low, but had more than doubled over the decade to 1995–6 (Fig. 4).[38]

The focus of the new federal government moved from direct industry intervention towards building a supportive policy environment for innovation. A passage from a 1995 OECD report on national innovation systems captures this approach:

> Innovation is a major determinant of the success of firms and of economies. The development and commercialisation of new products, processes, and services are key drivers of economic growth. Innovation depends on research and ready access and receptiveness to new technology and idea. It propels productivity, spawns new industries and transforms existing industries. Economies which can effectively foster and commercialize innovations will grow faster and will generate more jobs and higher living standards.[39]

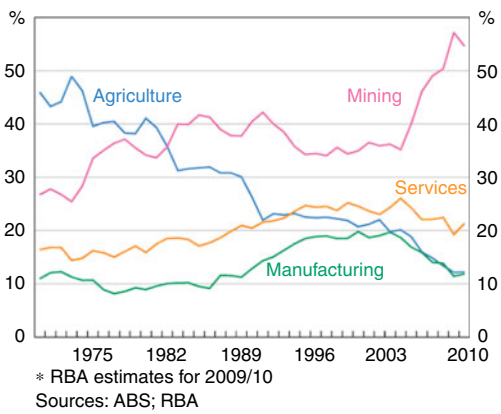


**Figure 3.** Exports by industry sector; share of nominal exports, financial years.

*CSIRO and technology transfer (McIntosh)*

For CSIRO the challenge in the latter years of the 1990s was to strengthen its industry technology transfer activities—to improve

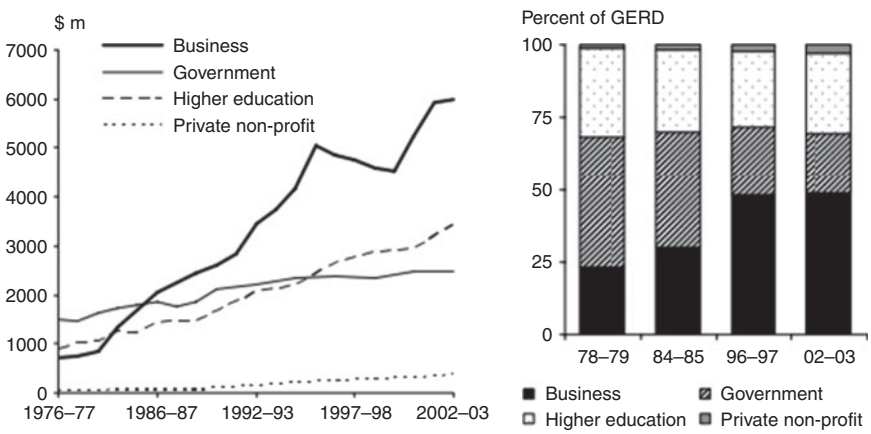


**Figure 4.** R&D expenditure by institutional sector and shares in total expenditure.

[35] Henry (2001) p. 41.
[36] Connolly and Lewis (2010).
[37] McKinsey and Company and Australian Manufacturing Council (1993); Rennie (1993).
[38] Shanks and Zheng (2006).
[39] OECD (1995).

**Table 3. External funding by source 1994–95 to 2000–01 (current dollars).**
Data from CSIRO 2000/01 Annual Report

| | External earnings | Australia private sector | Australian Governments | RIRDC | CRC | Overseas entities | Other |
|---|---|---|---|---|---|---|---|
| 94/95 | 195.6 | 61.2 | 49 | 44 | 26.9 | 8.3 | 9.1 |
| 95/96 | 202.1 | 66.4 | 49.8 | 41 | 28.4 | 8.9 | 7.9 |
| 96/97 | 221.6 | 74.7 | 48.4 | 44.2 | 34 | 11 | 9.2 |
| 97/98 | 226.1 | 77.5 | 52.3 | 40.3 | 32.5 | 15.5 | 8.1 |
| 98/99 | 230.6 | 69.4 | 63.1 | 40.8 | 31.3 | 21.9 | 4.1 |
| 99/00 | 249.5 | 74 | 68.6 | 40.7 | 30 | 31.4 | 4.9 |
| 00/01 | 248.3 | 75.2 | 66.8 | 40.8 | 27.6 | 32.7 | 5.2 |

commercial practices, to deliver important outcomes while meeting external funding requirements and to strengthen commercial skills and professionalism across CSIRO.

McIntosh had inherited a revised organisational structure, introduced in 1996.[40] This involved individual CSIRO scientists reporting to their divisional chiefs, but also reporting to one of several industry sector coordinators. One of the benefits of this structure from an industry perspective was that each sector had an oversighting Sector Advisory Committee that comprised industry, government and community representatives. This gave research users an important consultative role in priority setting and resource allocation. The Sector Advisory Committees were directly involved in the 1997 triennial priority setting exercise and in the process described by Dr McIntosh of 'directing the marginal dollars to where they yielded the greatest benefit to the Australian taxpayer'.

The growing recognition of the importance of small–medium-sized enterprises (SMEs) in global economic growth had prompted an external review of CSIRO's support for SMEs,[41] and this became a priority for the appointed group of CSIRO commercial Industry Liaison Managers (ILMs).

The push for increased professionalism in CSIRO's commercial practice was in response to a growing awareness of potential commercial risks. This followed several legal disputes mounted against CSIRO in the early 1990s, such as Cassegrain,[42] and Charter Pacific.[43] A comprehensive commercial practice manual finalized in 1996 provided commercial guidelines and best practices in relation to the handling of intellectual property and commercial information. A *Guide for CSIRO Staff to Commercial Practice* was made available in 1998.[44]

The maturation of CSIRO's commercial activity in late 1990s also saw increased formal and informal networking arrangements for commercial staff and the establishment of a commercial committee reporting to the CSIRO executive. In 2000/1 the total number of commercial staff in CSIRO had grown to 137. In that year CSIRO signed 168 new licence, option and assignment agreements, and 2494 contracts with a total value of $173.4 million.[45]

Table 3 shows the sources of external funds for CSIRO in the seven-year period to July 2001.

## Technology transfer practices

One can see a major change in the pattern of CSIRO's technology transfer activities during the 1980s and 1990s, away from the pattern that had prevailed till then. *Non-commercial transfer* continued to be important but there was a major shift towards *commercial transfer* and *new company generation*, two modes that had been less important in previous decades. The different modes of technology transfer are set out in greater detail Fig. 5.

## Commercial transfer

### *Collaborative research*

The expansion of collaborative research was perhaps the defining change in the CSIRO's approach to technology transfer to industry. This transfer path involves sharing the costs, risks, and expected benefits with a commercial partner and the shared development of intellectual property. Although there had been collaborative projects in the past these had been infrequent. Some notable examples in the 1970s included the Sirospun textile process,[46] the polymer banknote project,[47] and consortium projects involving the Australian Minerals Industries Research Association (AMIRA). By the early 1990s collaborative research had become common across the organisation and embedded in research planning processes.[48] The number of interactions grew through the 1990s and in 2001 CSIRO was formally involved with a total of 1981 private sector clients.[49]

Three forms of research collaboration warrant particular attention: strategic alliances, research consortia and syndicated R&D projects.

[40] Frater (1995).
[41] CSIRO (1993*a*).
[42] CoResearch (1993).
[43] CSIRO (1993*b*).
[44] CSIRO (1998).
[45] Australian Research Council and CSIRO (2002).
[46] Ward (2011).
[47] Solomon and Spurling (2014); Spurling (2019).
[48] Upstill (1995*a*).
[49] Australian Research Council and CSIRO (2002).

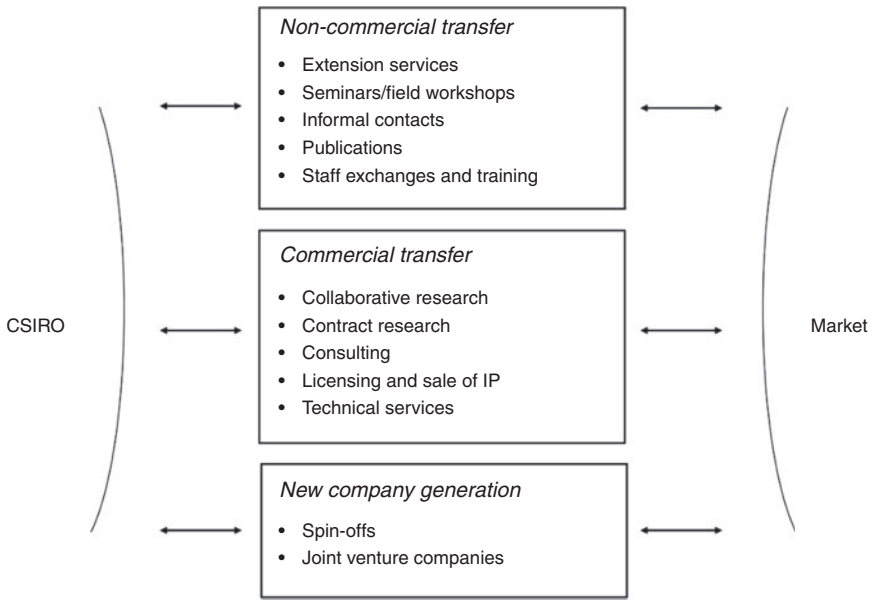


**Figure 5.** Technology transfer pathways for CSIRO (figures adapted from Upstill and Symington (2002)).

*(i) Strategic alliances*

One approach to collaborative research was via strategic relationships with companies that delivered long-term benefits to the Australian economy and drew on the capabilities of the whole organisation, not just those of the initiating group or division. The strategic alliances involved multi-project programs in pre-defined areas of research.

The first of these was the Boeing–CSIRO strategic alliance negotiated by Institute Director Dr Colin Adam.[50] In 1989, a memorandum of understanding with Boeing was signed with initial investment of $9 million over three years in four projects with projects in carbon fibre, composites, aluminium casting, and ozone studies. The interactions between Boeing and CSIRO were managed at the corporate level, at the commercial/legal and at the technical/project level. There were model agreements, a process for formal technical reviews and timely management and dissemination of information. Crucially there was an agreed relationship structure (Fig. 6).[51] These arrangements have stood the test of time. On 27 February 2019, the minister for industry, science and technology, announced twenty new Boeing and CSIRO joint research projects. Over the thirty years the two organisations had jointly invested more than $180 million in a wide variety of technologies including manufacturing processes, coatings, fire-retardants and data analysis software.[52]

In 1989, the chief executives of CSIRO and Broken Hill Proprietary Company (BHP) signed a five-year research agreement to invest in CSIRO research across the areas of waste management, remote sensing and gas conversion. This was a productive platform for market-oriented research by the two parties (although the technically successful anaerobic digestion/waste management project was closed following a change in BHP's commercial strategy). Other multi-project alliances undertaken by CSIRO included the Sydney Water Board, Australian Defence Industries (ADI) and Memtec.

*(ii) Research consortia*

Another form of collaborative research that emerged was consortium research, in which CSIRO initiated joint research projects with multiple partners, generally including companies. Examples included:

- alumina production processing joint research through AMIRA involving 13 companies and three CSIRO Divisions and addressing Bayer process improvement and flocculation;
- the Australian Automotive Technology Centre with Ford, Toyota, Mitsubishi and Nissan, in a pre-competitive low-pressure aluminium die casting project;
- Safe-T-Cam traffic monitoring system developed in collaboration with the Road Transport Authority (RTA) and Telecom;
- the high temperature superconductivity program involving BHP, Metal Manufactures and the University of Wollongong; and
- the Port Philip Environment Study with Melbourne Water and Melbourne Parks and Waterways.[53]

The consortium model lay at the heart of the Cooperative Research Centres program introduced in 1990. The CRC program brought together industry, university and government players and

[50] Spurling and Healy (2018).
[51] Thacker (2000).
[52] Andrews (2019).
[53] Upstill (1995*a*).

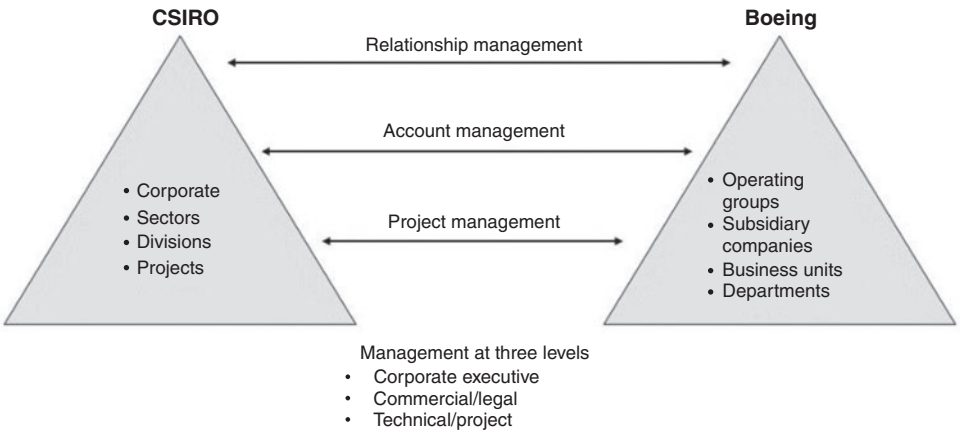


**Figure 6.** Business relationships between CSIRO and Boeing.

**Table 4. Examples of commercial outcomes of CSIRO involvement in CRCs 1990–2000.**

| CRC | Year | Other partners included | Commercial outcome |
|---|---|---|---|
| Eye Research & Technology | 1991 | University of NSW and Ciba Vision | Day–night contact lens |
| Materials Welding and Joining | 1992 | University of Adelaide, University of Wollongong and Australian Pipeline Industry Association | Pipeline laying technology |
| Cardiac Technology | 1992 | University of NSW and the Royal North Shore Hospital | Spin-off (Elastomedic) |
| AJ Parker CRC for Hydrometallurgy | 1992 | AMIRA, Comalco, Curtin University and Murdoch University. | Solvent extraction and thickening technologies |
| Polymer Blends/Polymers | 1992 | ANSTO, Monash University, RMIT University, UNSW, Qenos Pty Ltd, Olex, Orica | Polymer cable technology |
| Photonics | 1992 | Australian National University, RMIT University, UNSW, Uni. Melbourne, Uni. Sydney | Spin-offs—Redfern group companies |
| Cattle and Beef Industry | 1993 | Queensland Department of Primary Industries, Pfizer, InterVet, Genetic Solutions | Vaccine and gene marker test |
| Alloy and Solidification/Metal Manufacturing | 1993 | University of Queensland, Swinburne University of Technology Deakin University and the Australian Die Casting Association | Range of novel manufacturing technologies |
| Water Quality and Treatment | 1995 | RMIT University, University of Adelaide, most metropolitan water authorities | Pathogen control technologies |
| Bioproducts | 1999 | Australian Wine Research Institute, University of Adelaide, University of Melbourne, University of NSW, Carlton United Breweries and Goodman Fielder | Food processing technologies |

filled an important bridging role in the innovation system. It extended the opportunities for successful technology transfer to industry and the program was favourably reviewed in 1998 and 2003.[54] By 1999, CSIRO was a member in 53 of the 67 CRCs then in place.[55]

Table 4 lists some of the commercial outcomes from CRCs in which CSIRO was involved.[56]

*(iii) Syndicated research and development*

Another, ultimately less successful vehicle for technology transfer to industry was the R&D Syndication Program that was introduced in November 1987 as part of the governments tax concession scheme to promote private sector R&D investment. It was intended to allow a group of companies to form a syndicate to undertake R&D projects that were beyond the resources of, or considered too risky, for a single company to undertake, and was employed as an instrument for financing R&D in research companies with tax losses. The scheme was subsequently expanded to include financial institutions as syndicate members. CSIRO was encouraged to join the scheme and in a letter in 1989 the industry minister wrote that:

> Providing the syndication funding proposed by CSIRO meets both the IR&D Board and Taxation Office guidelines (and) … I view the use of syndicated funds under the 150% Taxation Scheme as an

[54] Mercer and Stocker (1998); Howard Partners (2003); OECD (2003).
[55] CSIRO (1999).
[56] Allen Consulting Group (2005); Insight Economics (2006).

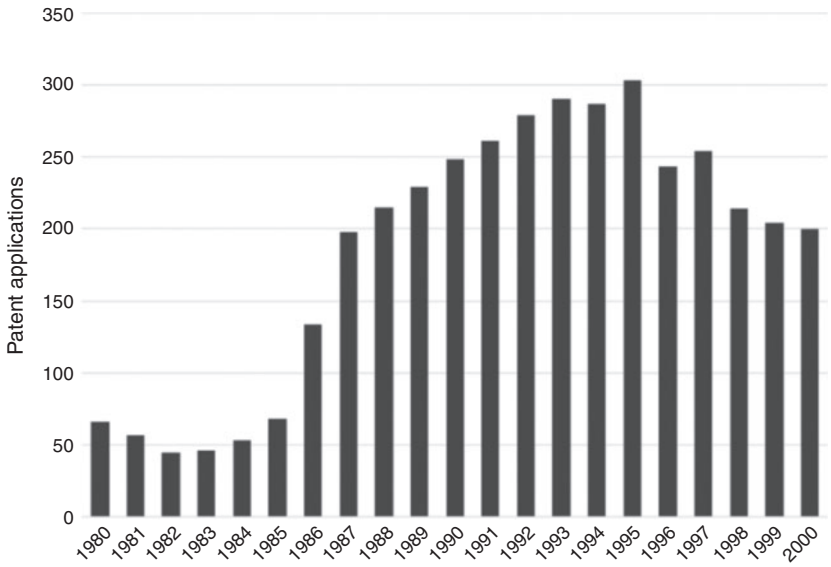


**Figure 7.** CSIRO patent applications in Australia 1980–2000, by year of filing. Data drawn from IP Australia, http://pericles.ipaustralia.gov.au/ols/auspat/ (Accessed on 18 August 2019).

appropriate extension of Commonwealth support for the Australian manufacturing industry.[57]

CSIRO took part in three syndicates from 1992–8—'Anti-virals' (Macquarie Bank and AMRAD Corp.), 'Telecommunications' (Westpac and a consortium from the Australian telecommunications industry) and 'Rumentek' (Macquarie Bank and Rumentek Industries). The 'put' option was triggered in each of these syndicates meaning that financial institutions were not sufficiently interested in exploiting the results of the research.

*Patenting and licensing*

Patenting is often the preferred method to protect intellectual property and the number of patents serves as an indicator of commercial intent in research. Fig. 7 shows the annual number of patent applications in Australia by filing date. It reveals a marked rise from less than 50 per year at the start of the 1980s to a peak of over 300 per year in 1995.

Another measure of commercial activity is licensing income received by CSIRO. Fig. 8 shows the royalty flow over the period from 1980.[58] The exceptional entry for 1988 is attributable to payment for the Banknote Project. There is typically a lag period between acquiring patents and realising the income flow, so the data in Fig. 8 understate the financial impact. Notably it does not include royalties associated with the WiFi patents taken out by CSIRO in the early 1990s.[59] A successful legal battle in the United States which was resolved in 2008 led to CSIRO receiving more than $500 million dollars in settlements. Some prominent CSIRO inventions licenced during this period are listed in Table 5.

## Generating new companies

*Spin-offs*

Just a few start-up companies based on CSIRO research had been formed before 1980. During the 1980s this changed (see Fig. 9). In the event, 42 spin-off companies were generated by CSIRO in the period 1985–95 at an average rate of 1.3 per year for every US $100 m of R&D funding provided to CSIRO by the Government.[60] Over the period to 1998, some 52 CSIRO spin-off companies were formed. As of 2000 these had a total annual turnover in excess of $200 million and employment of over 1000. Table 6 lists some prominent spin-offs from this era.

Fig. 10 shows three different routes to creation of start-up companies by CSIRO.[61] The first, spin-offs (shown here as 'direct spin-offs') involved the movement of CSIRO staff and CSIRO intellectual property. Other routes are through the generation of 'indirect' spin-off companies through CSIRO staff leaving to set up new companies drawing on knowledge acquired during careers in CSIRO but not on specific CSIRO intellectual property, and by the creation of companies based on intellectual property acquired from CSIRO. Several successful new companies have been formed through the latter routes, as shown in Table 7.

*Joint venture companies*

The 1978 and 1986 amendments to CSIRO's Act permitted the organisation, subject to ministerial approval to hold equity in companies which were directed towards getting its research applied and commercialized. Examples of companies in which CSIRO held equity are shown in Table 8.

[57] CSIRO (1989*a*).
[58] Data drawn from CSIRO Annual Reports 1980–2000.
[59] Healy (2019).
[60] Thorburn (1997).
[61] Upstill and Symington (2002).

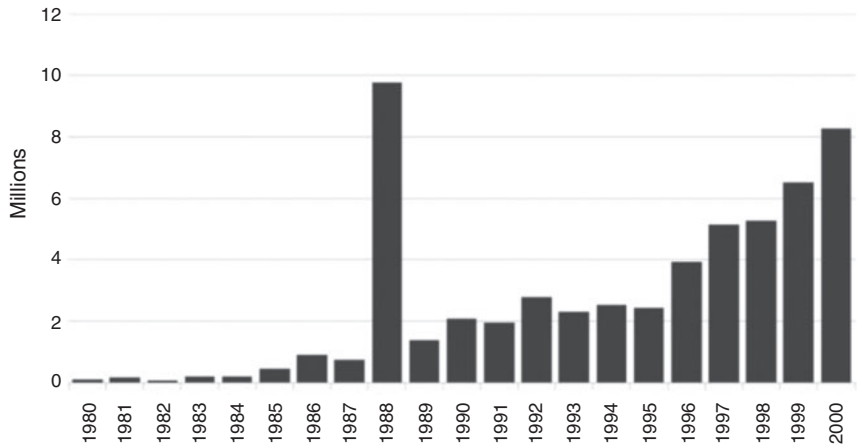


**Figure 8.** CSIRO royalties 1980–2000.

**Table 5. Licensing of CSIRO intellectual property.**

| Research Outcome | Year | Licenced company | URL |
|---|---|---|---|
| Influenza drug (Relenza) | 1985 | Biota (& Glaxo Wellcome) | http://csiropedia.csiro.au/Relenza/ |
| CDT pulse welder | 1984 | Welding Institute of Australia Pty Ltd | https://csiropedia.csiro.au/synchro-pulse-controlled-drop-transfer-welding-system/ |
| Coal Scan online ash analysis | 1982 | Mineral Control Instrumentation/ Scantech Ltd | |
| Extended wear contact lens | 1999 | Ciba Vision, Novartis | |
| Sirospun for light weight woollen fabrics | 1980 | Warren & Brown | https://csiropedia.csiro.au/sirospun/ |
| SIROFLOC water treatment process | 1981 | Davy McKee Pacific | csiropedia.csiro.au/sirofloc/ |
| Liteslice monitoring of rail wear | 1984 | Aldetec | |
| Grazfeed stock-feeding software | 1989 | Horizon Agriculture | https://csiropedia.csiro.au/grazfeed/ |
| BC Aider expert system for building industry | 1991 | Butterworths | |
| Vaccine for infectious bursal disease | 1997 | Websters, Biotechnology Australia. | http://csiropedia.csiro.au/Infectious-bursal-disease-virus-vaccine/ |
| Sirospun wool spinning | 2000 | Woolmark | https://csiropedia.csiro.au/sirospun/ |

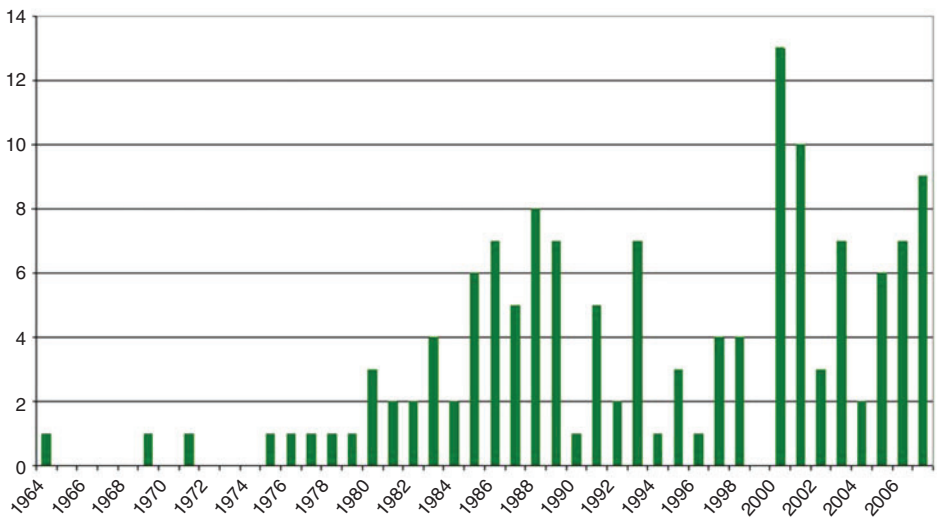


**Figure 9.** Spin-off companies generated by CSIRO, by year.

**Table 6. Examples of CSIRO spin-off companies.**

| Research area | Year | Spin-off company |
|---|---|---|
| Smelting technology for non-ferrous metals | 1981 | Ausmelt |
| Crop protection chemicals | 1985 | Dunlena (with DuPont) |
| Biopharmaceutical products | 1985 | Peptide Technology Ltd |
| Ceramic materials | 1985 | ZTech (with ICI Australia) |
| Wood treatment products | 1988 | Preschem |
| Design of software for aviation industry | 1988 | The Preston Group |
| Audio processing software & hardware | 1992 | Lake DSP |
| Biopharmaceuticals, novel growth factors | 1988 | Gropep |
| Exploration spectrometry equipment | 1991 | Integrated Spectronics |
| Solid oxide fuel technology | 1992 | Ceramic Fuel Cells Pty Ltd |
| Drug development | 1996 | Starpharma |
| Communications technology | 1997 | Radiata Communications |

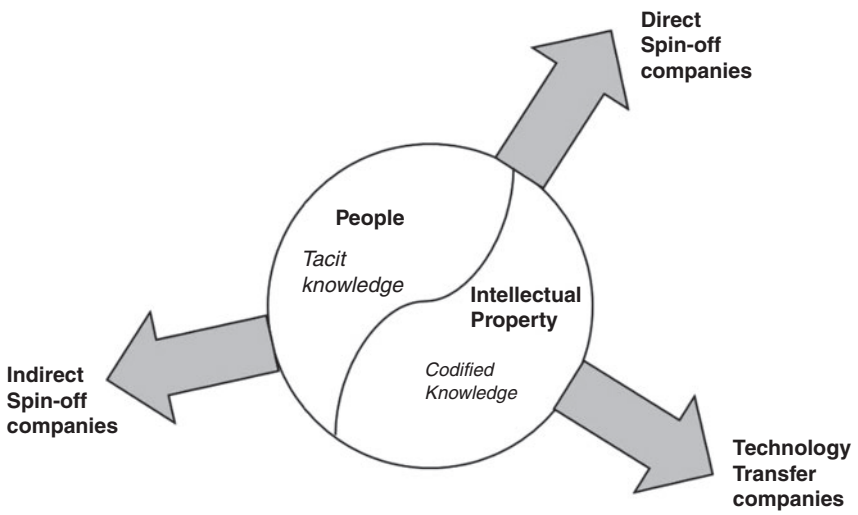


**Figure 10.** Pathways to start-ups from CSIRO.

**Table 7. Examples of technology transfer and indirect spin-off companies.**

| Year | Name | CSIRO Division | Nature of Business |
|---|---|---|---|
| | *Technology Transfer Cos.* | | |
| 1976 | Nilcra/Z-tech | Materials Science | Ceramics manufacture |
| 1982 | Betatene Pty Ltd | Chemical Technology | Production and marketing of natural chemical products |
| 1985 | SRL Plasma Ltd | Manufacturing Technology | Manufacture of hazardous waste destruction units |
| 1992 | Test Technology Pty Ltd | Manufacturing Technology | Manufacture of battery testing equipment |
| 1992 | Rumentek Australia Pty Ltd | Animal Production | Manufacture of animal food supplements |
| 1997 | Elastomedic | Molecular Science | Biomedical products |
| | *Indirect Spin-offs* | | |
| 1989 | Granitgard | | Manufacture of anti-termite products |
| 1989 | Strata Control Technologies | | Consulting on rock mechanics for mining industry |
| 1992 | Ausspec International | | Consulting on imaging for mining industry |
| 1993 | Microbial Screening Technologies | | Biological analysis |

## Non-commercial transfer

Non-commercial transfer continued to be important through means such as publications, seminars, workshops and staff exchanges. Moreover, the traditional transfer approach adopted by CSIRO in relation to rural industries—use of state government extension agencies to introduce new technologies to industry

**Table 8. Examples of CSIRO joint equity companies.**

| Company | Industry partners | Activity |
|---|---|---|
| Dunlena | DuPont (Australia), AIDC | Agricultural chemicals |
| Gene Shears | Groupe Limagrain | Gene modification |
| Gropep | Luminus, Child Health Institute, Dairy R&D Corp | Growth factors and peptides |
| Queensland Metals Corp | Commonwealth, Queensland governments, Mount Isa Mines, Queensland Metals Corp, Ube Industries | Magnesite processing |
| Coal Waste Combustion | Costain, Ecogen, National Mutual, Mitsubishi | Coal processing |
| Ceramic Fuel Cells Ltd | Pacific Power, SECV, BHP, ETSA, Energy R&D Corp | Fuel cell technology |

communities—remained viable in cases where the beneficiaries were industries, rather than individual companies.[62] CSIRO remained uniquely positioned to bring together research teams with the breadth and depth to deal with industry problems such as grain storage technologies, weed and pest control (for example: the weed *Salvinia molesta*) and virus threat to the horse-breeding industry. Some notable successes drawn from the 1980s and 1990s are shown in Table 9.

### *Informal contacts*

As CSIRO's direct contacts with Australian manufacturing industry grew, so did the level of informal interactions. Informal contacts have always been an important, if unrecorded form of technology transfer practised by CSIRO, for example through scientist involvement in professional organisations such as Engineers Australia and the Royal Australian Chemical Institute and industry associations such as the Metals and Trade Industries Association or the Plastics and Chemical Industry Association). A 1995 report looked at the contribution of advice and information given by CSIRO researchers to industry through informal networks.[63] It found the extent of contacts is large and represented a significant investment of time by CSIRO's professional scientists. On the basis of a six-month survey period in 1994, the report found each of three CSIRO manufacturing divisions was involved in over a thousand industry-initiated contacts per year, mainly from SMEs. These resulted in provision of technical advice (65%), referral to other expert sources (20%) and discussion of R&D opportunities, which might lead to collaborative research (15%). Well established research groups were involved in upward of three hundred contacts per year.

## Summary and discussion

Under its 1949 Act, CSIRO was mandated to promote Australia's primary and secondary industries.[64] The technology transfer approach it had adopted to achieve this had proved successful during the 1950s and 1960s and had been principally directed towards support for rural industries. There was consultation with industry associations and agencies but the transfer of research outcomes was left largely in the hands of state-based extension agencies.

The halcyon economic days of the 1950s and 1960s were replaced by a difficult external economic environment in the 1970s and CSIRO's approach to technology transfer came under question. In 1977, the Birch report called for CSIRO to become more 'applications-oriented' and in 1978 the organisation's legislation was amended and technology transfer became a key function. CSIRO was slow to change, perhaps for reasons of institutional inertia born of its past success in delivering valuable outcomes for the agricultural sector, but also because Australia's manufacturing sector remained unresponsive and inward looking behind tariff walls. But this situation changed after the 1983 federal election. The incoming government was driven by a sense of economic crisis and the need to grow the international competitiveness of Australia's industries, notably manufacturing, through technology and innovation. The political signals to CSIRO from government were strong and clear and were reinforced by a wide-ranging program of economic reforms. In particular the external earnings requirements placed on CSIRO and which lasted 1989–2003 were a spur to interaction with Australian industry and the commercialisation of its research.[65]

### *Adapting to a changing environment*

CSIROs approach to technology transfer changed as part of an adaptive response to external pressures from government, opportunities afforded by the changing industry environment, and as an expression of the administrative and structural reforms that CSIRO progressively introduced from the early 1980s. CSIRO's response to the challenges it faced during this period was resourceful and wide-ranging, as revealed in the analysis of the three mini-eras in preceding sections of this paper.

Speaking broadly the main change was the shift from non-commercial technology transfer pathways (knowledge transfer in the terminology of Gopalkrishnan and Santoro) towards increased commercial technology transfer pathways, augmented by new company generation.[66] This entailed a more active role in technology transfer for CSIRO, as required under the organisation's new legislative mandate, and was better suited to the increased importance of manufacturing industry and mining sectors. Collaborative research involving continuous interaction with companies and other research users became the norm, rather than the exception, at project and program level. New companies were generated and commercial capabilities expanded rapidly.

[62] Upstill (2019).
[63] Upstill (1995*b*).
[64] Commonwealth of Australia (1949).
[65] Batterham (2002).
[66] Gopalkrishnan and Santoro (2004).

**Table 9. Examples of CSIRO-led non-commercial transfer 1980–2000**

| Research Outcome | Year | Beneficiary |
|---|---|---|
| Salvinia weed biocontrol | 1980 | Water authorities |
| Control of iodine deficiency disorder | 1980s | Health authorities(via UNICEF, WHO committees) |
| Barrier reef image analysis for zone planning | 1985 | Australian Survey Office/Great Barrier Reef Marine Park Authority |
| SIROFLO for safe grain storage | 1988 | Grain-handling authorities/wheat industry |
| Diagnosis of equine morbillivirus | 1994 | Horse racing industry |
| Port Phillip Bay environmental study | 1992–2004 | Victorian water agencies |
| Seabed ore deposits | Early 1990s | Mineral exploration industry |
| Geochemical haloes in Australian regolith | 1986 | Australian gold mining industry plus one-on-one collaborations with firms |

*Looking back*

The early 1980s to the late 1990s was a singular era for CSIRO in terms of its relationship with Australian growth of a more interactive approach to and increased direct engagement with the commercial users of CSIRO's research during this period.

By the late 1990s, though, the situation had begun to change. The bipartisan approach to policy reforms receded as the external economic environment improved. The macroeconomic circumstances that had triggered the federal government to turn to CSIRO had passed, and Australia embarked on long period of sustained economic growth. The manufacturing sector had lifted its technology outputs and R&D spending but its importance had shrunk within the Australian economy as the services and minerals sectors grew. CSIRO was a smaller national research player than it had been two decades before. Private sector R&D had risen and CSIRO's slice of total government R&D expenditure had fallen from 15% in 1980 to 8% in 2000. The implications for CSIRO were not fully evident at the time: the Mortimer report in 1997 had recommended CSIRO increase its external earnings and double its support for spin-off companies.[67] CSIRO Chairman Charles Allen had written in 2001 of the need for 'growing CSIRO budget not only through increased appropriation but also through increased commercial links',[68] and in 2002 CSIRO announced 'the bold target of increasing its business by 50 per cent by 2006'.[69]

In the event CSIRO changed course following the government's 2002 *Innovation Report*.[70] This prompted a reconsideration of CSIRO's role within Australia's national innovation system,[71] and a shift towards an organisation more driven by national research goals and less influenced by industry. It adopted a hybrid organisational structure focussed on flagship projects with national objectives. Public agencies played an increasing role as a source of external earnings relative to that of private sector companies and the role of industry advisory committees was trimmed back, for example, in losing their capacity to sign off on CSIRO's strategic plans.[72]

In summary, we see the early 1980s to the late 1990s as an exceptional period in the organisation's history, during which CSIRO re-envisaged its role and engaged actively and deeply with Australian industry. After a sluggish start, CSIRO showed considerable nimbleness and resilience in transforming embedded organisational practices and achieving substantial outcomes. For many of those involved it was an enlivening period of change, driven by a sense of urgency and purpose.

## Conflicts of interest

The authors declare no conflicts of interest.

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[69] Commonwealth of Australia (2002) p. 32.
[70] Commonwealth of Australia (2002).
[71] Sandland and Thompson (2012).
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