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New Structures, New Strategies: CSIRO's Changing Role in Australian Innovation

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Abstract *CSIRO's role in Australian innovation has evolved over the years in response to changes in the external environment and within Australia's national innovation system. The process of organisational change has been characterised by a series of restructurings—in 1978, 1988, 1996 and 2001—and accompanying shifts in the organisation's strategic directions. In this paper we look at the process of organisational change in an historical context, looking at the evolving external environment, the legislative and management background, and the shifts in the organisation's strategic directions. The change process is interpreted from a punctuated equilibrium perspective. We propose that discontinuous, rather than continuous change, is the way that a complex and diversified organisation like CSIRO adjusts to a changing external environment and, moreover, that independent public reviews have an important role in this process. In the light of major changes in the Australian and scientific landscapes over the past two decades we suggest it is time to look again at CSIRO's role and the sustainability of its internal management arrangements.*

Keywords: CSIRO; organisational change; public research; punctuated equilibrium; restructuring

Introduction

In this paper we look at the organisational change process in CSIRO, Australia's largest public research organisation. CSIRO has over 6,500 staff and conducts research in the areas of agriculture, manufacturing, services, communications & information technology, minerals & energy, transport & infrastructure, health and the environment. (It does not operate in the areas of medical, nuclear and defence research, which are the province of other public research institutions.) In 2005/6 its total income was A$930m, comprising A$594m directly appropriated from the federal government, with the balance from industry and other government sources:[1] it accounted for 10% of Australian public funded R&D and just over 6% of Australia's total R&D expenditure.

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Although it is predominantly funded by the Australian federal government, CSIRO operates with a high degree of independence and a broad mandate. Its legislated principal functions are: (a) to carry out scientific research for any of the following purposes: 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; and (b) to encourage or facilitate the application or utilisation of the results of such research.[2]

CSIRO's role has evolved over the years as it has adapted to the changing scientific, political and economic environment, notably in the nature and scope of its research, in its collaborative activities and its technology transfer activities.[3] In this paper we look at the process of organisational change in CSIRO, particularly the disruptive adjustments to structure and strategy that occurred in 1978, 1988, 1996 and 2001. We address the apparent paradox that an institution vested with a high degree of institutional independence and ability to chart its own future, should nonetheless, from time to time, undergo wrenching organisational change.

The structural changes at CSIRO since 1949 are shown in Table 1 and discussed in the next section.

Changing Corporate Structures

1949

In 1949, with the passage of the *Science and Industry Research Act*, CSIRO took the mantle of Australia's national research laboratory from its predecessor the Council for Scientific and Industrial Research (CSIR). The new organisation had an extensive mandate, namely

> the initiation and carrying out of scientific researches and investigations in connexion with, or for the promotion of, primary or secondary industries in (Australia) or in connexion with any other matter referred to the Organization by the Minister.[4]

CSIRO was set up with a flat division-based structure, similar to that of CSIR. Research divisions were primarily organised on disciplinary lines with chiefs of divisions reporting to the Executive, and the Chairman reporting to the Minister. It was a time when there was little private sector R&D and CSIRO dominated the non-defence Australian scientific landscape. Lesser roles were played by state-based organisations and (until the 1960s) the university sector. In 1950–51 CSIRO accounted for 26% of total federal R&D expenditure of £9.9 million (defence R&D was 64% of this total).[5]

The decades following the Second World War were a time of pervasive scientific optimism[6] in Australia and abroad. CSIRO's scientific achievements in a variety of fields ensured it a high standing.[7] Moreover it was a time of expansion; the CSIRO Chairman for 1959–70 noted these were times when research 'money was easy to obtain and the increase in our annual appropriation from the Commonwealth government was quite large so growth, therefore, followed suit'.[8] The organisation retained a high degree of autonomy in the way it allocated funding for research. Considerable authority was vested in the chiefs of divisions to decide on and conduct research judged to be in the national interest. Notably this

Table 1. Structural change at CSIRO since 1949

Date	Structure	Characteristics
1949	Flat, functional structure	● Chiefs of divisions reporting to the CSIRO Executive, and the Chairman of the Executive reporting to the Minister. ● The Executive empowered to make recommendations to the Minister with respect to the policy and work of the organisation; the funds required for carrying out the work of the organisation; and the allocation of funds made available for carrying out that work. ● External advice to CSIRO through an Advisory Council and a set of state-based committees.
1978	Research institute structure	● Divisions grouped into five research institutes—the Institute of Animal & Food Science, Institute of Biological Resources, Institute of Industrial Technology, Institute of Physical Sciences, and the Institute of Energy and Earth Resources and a Bureau of Scientific Services. ● Institute directors had responsibility for research management and co-ordination. ● External advice to CSIRO through an Advisory Council and a set of state-based committees.
1988	Industry institute structure	● Divisions regrouped by industry sector—Institute of Industrial Technologies, the Institute of Information Science & Engineering, the Institute of Minerals, Energy & Construction, the Institute of Animal Production & Processing, the Institute of Plant Production & Processing, and the Institute of Natural Resources & Environment. ● Divisional programmes revised and amended to fit with the strategic directions of the new institutes. ● Institute directors given substantial administrative and budgetary powers, and each had support staff responsible for planning and evaluation, finance and commercialisation. ● CSIRO Board established in 1986, the CEO reported to the Board with the Board Chairman reporting to the Minister. ● CEO and Institute Directors constituted the Executive Committee.
1996	Matrix structure	● Hierarchical institute-based structure replaced by a new matrix organisation. ● Researchers now had two lines of reporting, one line, which was primarily discipline-based, was to their respective division chiefs, and the other was to the sector coordinators responsible for relationships with industry partners. ● Sector Advisory Committees played active role in CSIRO triennial priority setting exercise.
2001	Hybrid structure	● Matrix structure dismantled in favour of a hybrid structure focused on a set of large cross-divisional science based 'national flagship projects'. ● Sector Advisory Committee arrangements progressively dismantled and management structures changed. Divisions currently arranged into five groups: Agribusiness; Energy; Information, Communications & IT; Manufacturing, Materials and Minerals; and Environment. ● Six, since expanded to nine, large cross-divisional flagship projects established, with ambitious 10-year goals.

included the rural sector, indeed before wool prices dropped sharply at the end of the 1960s, 'wool research (broadly defined) had absorbed almost half of the total funds available'.[9]

Excellence in research continued to be the principal measure of success. In the rural sector there were well established extension programmes, but in the manufacturing sector there were few examples of commercial success. The occasional

outstanding achievements, such as the atomic absorption spectrophotometer, appear now as the products of lone heroes such as Sir Alan Walsh[10] rather than systematic CSIRO processes. Although CSIRO was a source of excellent research

> … because it was assumed there was no knowledge technology transfer problem the discipline based divisions were often placed physically and industrially at arms-length from consumers. … Thus research programs were inclined to take on a life of their own and to take scientific criteria as their point of reference.[11]

By the mid-1970s though, the environment for public funded research was changing. There was slower economic growth, rising inflation, oil shocks, growing environmental concerns and increasing international competition. The economic and scientific optimism of earlier decades seemed less fitted to the times. In Australia there were new challenges with the emergence of the minerals and energy sector, and the relative decline of the importance of rural industry to the economy.

By the mid-1970s CSIRO still accounted for almost one quarter of all Australian R&D, and approximately one third of government funded R&D. But it had reached the limits in real terms of its Treasury appropriation.[12] It was no longer the dominant non-defence research provider that it had been years before. University research funding finally reached broad parity with CSIRO in the mid-1970s and as the CSIRO historian Boris Schedvin notes 'even in the absence of an economic crisis this was bound to force a reappraisal of CSIRO's role'.[13]

1978

The changed external environment provided the backdrop to major changes in structure and strategy for CSIRO. An inquiry into CSIRO commissioned by the federal government in 1977 and chaired by Professor Arthur Birch[14] recommended a number of changes to the organisation. Notably these included a shift in the balance of CSIRO's research from longer term, fundamental research toward strategic-mission orientated research and the greater involvement of end-users in the allocation of research funding. The recommendations of the report were broadly accepted by government and embodied in amendments to CSIRO's Act. Introducing the legislative changes, the Minister stated CSIRO's 'research would be principally longer-term strategic mission oriented research, although fundamental and tactical problem oriented research will be pursued when it is related to the Organisation's role'.[15]

As a consequence CSIRO became a hierarchical institute-based structure. Under a new Chairman, Dr Paul Wild, divisions were grouped by disciplinary area into five institutes—Animal & Food Science, Biological Resources, Industrial Technology, Physical Sciences, and Energy & Earth Resources. The newly appointed institute directors had responsibility for research management and co-ordination and were charged with leading change in CSIRO's research and interaction with research users. In 1984 Sirotech, an 'arms-length' technology transfer office, was established to help divisions commercialise research.

Despite the legislated shift toward a focus on end-user needs, the CSIRO Executive stood fast on what it saw as essential matters of policy, stating for example in 1979 that 'the setting of strategic priorities for and the management of strategic research are best handled by a scientifically oriented body consulting with users

and their representatives'[16] and, that while 'CSIRO has a responsibility to carry work forward to a point where it can reasonably leave further development to future users … CSIRO should not do industry's job'.[17] Moreover, the new institutes had limited support staff and divisional chiefs, who had less personal incentive to push for change, retained considerable power and independence.

During the 1980s the economic environment continued to be demanding for public research organisations. Australia was an international leader in the deregulation and market reforms which began in the 1980s, including large reductions to manufacturing tariffs. There was heightening awareness of the competitive pressures facing local industry, notably manufacturing, and of the need to grow new industries through research and innovation. Calls for closer interaction between public research institutions and the business sector were growing across the world. In the United States the 1980 Bayh–Dole Act mandated increased transfer of intellectual property derived from public funded research ('use it or lose it'). In a similar fashion research institutions in other countries were called upon to play a bigger part in national economic development—for example in the UK,[18] Canada,[19] New Zealand,[20] and India.[21]

1988

In 1985 the Prime Minister commissioned a public inquiry into CSIRO by the Australian Science and Technology Council (ASTEC). Its report recommended, *inter alia*, a 'shift in the central ethos from one which has been largely science-oriented to one which is largely applications-oriented'.[22] The recommendations gave strength and practical import to the Birch approach, and were broadly adopted by government and the CSIRO's Act was amended. A new Board was established, charged with determining CSIRO policy, ensuring it performed its functions, and giving directions to the Chief Executive. In addition CSIRO's commercial powers were extended to the carrying out of services, the making available of facilities for scientific research; and the ability to acquire a controlling interest in a company. CSIRO was expected to 'play a major role in contributing to the Government's program of restructuring and revitalising high-technology manufacturing, and in supporting the emerging information and space technology industries'.[23]

The spirit of the legislative changes was made clear by the Federal Minister of the time, Barry Jones:

> 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 back up and stimulate industry to do more for it.[24]

CSIRO was able to retain earnings from outside sources without this leading to a decrease in its appropriation. Subsequently the organisation was assigned an external earnings target of 30% of its total income, as a spur to grow its interaction with research users in industry and other sectors.[25] (This target was abandoned in 2002.)

The new Board commissioned the consultants McKinsey and Co to recommend organisational arrangements for CSIRO that would enable it to carry out its new

role. As a consequence CSIRO was restructured in 1988: six new industry-focused institutes were set up, namely Industrial Technologies, Information Science & Engineering, Minerals, Energy & Construction, Animal Production & Processing, Plant Production & Processing, and Natural Resources & Environment. Divisional programmes were revised to fit with the strategic directions of the new institutes. Institute directors were given substantial administrative and budgetary powers, and each now had support staff responsible for planning and evaluation, finance and commercial development. A new Chief Executive Dr John Stocker, who had considerable private sector experience, was appointed in 1990.

The subsequent changes in CSIRO were far-reaching. Industry advisory groups were set up to guide CSIRO research priority setting and resource allocation. A new priority setting process combined views from industry, government and community representatives on the 'attractiveness' of prospective research areas with scientific views on the 'feasibility' of this research; and this was linked to research funding changes.[26] The external earnings target led to a surge in applied and commercially relevant research. Technology transfer activities expanded and devolved from institutes to divisions as commercial expertise grew. The commercial arm Sirotech was wound up in 1992, and the traditional 'end-of-pipe selling' approach was replaced by an interactive commercial process involving sustained contacts with industry and community research users.[27] Collaborative research with other organisations and commercial partners grew considerably, for example through the Cooperative Research Centre programme established in 1990.

Notwithstanding these changes, in 1995 the CSIRO Board called for another review of the organisation's structure and performance which was chaired by CSIRO Institute Director, Dr Bob Frater.

1996

Adopting the course of action recommended in the Frater Report, the Board introduced a new matrix organisational structure in 1996. When introducing the relevant amendments to the Science and Industry Research Act the Minister noted that:

> the repeal (of institute arrangements) will enable a new research management system that clearly refocusses research activities on identified industry, economic or national benefit sector and enable CSIRO's various research divisions to work in full alliance, free of the limiting rigidities of the institute structure as identified during the CSIRO review.

The changes would mean 'customer involvement in CSIRO's priority determination processes be strengthened at strategic and sectoral levels' and it would allow 'CSIRO (to) strengthen its focus on meeting customer expectations, particularly in regard to understanding customer needs, delivery to schedule and budget, and more professional marketing and contractual negotiation'.[28]

The new matrix structure meant researchers now had two lines of reporting, one primarily discipline-based to their respective division chiefs and the other to sector coordinators responsible for relationships with industry partners. The 20-odd industry-based sectors drew on pre-existing sector advisory groups and divisions were progressively streamlined. A new Chief Executive, Dr Malcolm McIntosh, arrived in 1996 to implement the new arrangements.

A significant change was that research users now played a greater role in priority setting and in the planning of research. The triennial budget allocation processes in 1996 and 1999 involved the active participation of Sector Advisory Committees comprising senior representatives from industry, government and community organisations, with the committees having sign-off responsibilities for their respective triennial research plans and budgets. The priority setting process meant deciding where limited government funds should be spent, or, as Dr McIntosh noted, '… directing the marginal dollars to where they yield the greatest benefit to the Australian taxpayer'.

An accompanying change was the scaling up of technology transfer. Increased resources went to commercial activities, and spin-off companies were encouraged. Research collaboration with commercial partners increased and a comprehensive *Commercial Practices Manual* was introduced to streamline commercial practices. The first systematic analysis of the commercialisation of Australian public research[29] showed that in 2000 CSIRO filed 178 patent applications in Australia and the US, executed 168 licences, earned $9m in royalties, and generated 13 start-up companies. It had a total of 136 staff (full time equivalent) employed in commercialisation activities.

CSIRO was still a powerhouse of Australian science, and had achieved a measure of commercial success. However, research activity by universities, other public bodies and the private sector had continued to grow and by 1996–97 the CSIRO budget of $700m represented 12% of public funded R&D and just 8% of total Australian expenditure on R&D.

2001

The next restructuring followed the untimely death of Chief Executive, Dr McIntosh, in 2000 and the appointment in 2001 of his replacement Dr Geoff Garrett. Under the new Chief Executive the matrix structure was dismantled and a hybrid structure put in its place, which was focused on large cross-divisional national flagship projects. There were extensive changes in management structures and in personnel and an accompanying change in research strategy—away from responsiveness to industry demands and towards national research objectives/flagships.

The priorities framework was abandoned in favour of a process administered by a senior CSIRO committee, although research users continued to inform the process at a project level. The primary emphasis shifted toward research in support of longer term national objectives, with ancillary commercial outcomes. Sector Advisory Committees (down to seven from 22) no longer had sign-off on planning budgets and corporate priority-setting reverted to the CSIRO Executive, in consultation with external users.

The cross-divisional flagship projects were initially in the areas of Preventative Health, Light Metals, Food Futures, Energy Transformed, Water for a Healthy Country and Wealth from Oceans. These accounted for more than 25% of CSIRO's research budget and had ambitious 10-year national goals, for example,

- Preventative Health—to extend the part of their lives in which Australians are healthy and productive by 10 years, through early diagnosis and prevention;
- Light Metals—to double the economic value of Australian light metals production to $10 billion over 10 years while reducing environmental impact.[30]

The rationale behind the structural changes introduced in 2001 is not fully clear. The initial emphasis appears to have been on growing commercial income. 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'.[31] In addition, CSIRO announced in its 2002 Strategic Action Plan 'the bold target of increasing its business by 50 per cent to $1.3 billion by 2006'[32] but this target was later abandoned. The new approach involved rethinking CSIRO's role within the national innovation system. A statement on the 2003–04 CSIRO Strategic Plan by the new Chairman Catherine Livingstone (with CEO Geoff Garrett) acknowledged the 'need for a more clearly defined role for CSIRO in the National Innovation System and the need for a more focused organisational strategy. Central to the strategy was our thinking around CSIRO's essential and differentiated role in the NIS'.[33]

The changes have led to increased emphasis on cross divisional research and on longer term national objectives. Technology transfer continues to be important, and external earnings for CSIRO continue tracking at levels similar to those prevailing before 2001, despite the discontinuation of the government-imposed external earnings target.

Interpreting the Process of Change in CSIRO

Adjusting to a Changing Environment

The past five decades have seen significant changes in Australia. Tariffs have been reduced, the currency has been floated, and the relative importance of the manufacturing and service sectors to the economy has increased. Technology-based innovation is recognised as critical to survival in the global economy.

Despite its importance, CSIRO no longer dominates the Australian science and technology landscape as research by the private sector, by universities and other research agencies has grown. Today its ambit is wider and has broadened from rural and manufacturing sectors to minerals, ICT and services industries as well as the environment. It has extensive industry contacts and research commercialisation capabilities and wide involvement with industry.

CSIRO's role and strategic directions have changed in response to the changing external environment.[34] Of themselves these changes should not be surprising. The ability to adjust to the demands of a changing environment indicates vigour and a capacity for renewal and flexibility that organisations need if they are to endure.[35] Public research institutions are under continuing pressure to adjust to the changing national context. Indeed, according to Arnold *et al.*, the appropriate role for a public research institution

> at a given time depends on the needs of its users, (its) own perceived and actual expertise, the state of development of the national innovation system in which it plays a part and the uniqueness of its contribution to the functioning of that system.[36]

Continuous or Discontinuous Change?

What is striking about CSIRO is that the changes in corporate strategy have required organisational restructuring and disruptions to achieve major shifts,

for example, towards applications-oriented research, or greater customer focus or more effective technology transfer. Instead, it might have been expected that CSIRO—given its relative autonomy and its powers under its Act—should have been able to respond to the pressures of a changing environment, and the demands of stakeholders and research users without such disruptions.

In some aspects CSIRO has undergone continuous change since the earliest days, for example in the reshaping of its research portfolio in response to advances in science, or new patterns of industry demand, or the environment or even, more recently, national security issues. But there have still been four disruptive restructuring events which we have outlined above.

One way of interpreting this is through punctuated equilibrium theory. According to this theory, which stems from Kuhn's analysis of the history of science and of biological evolution, evolutionary change in human and physical systems is characterised by alternations between extended periods of incremental adaptation and brief periods of revolutionary upheaval or discontinuous change.[37] The theory has been extended to studies of organisational development[38] and organisational transformation, according to this view, involves

> relatively long time spans of incremental change and adaptation which elaborate structure, systems, controls and resources toward increased co-alignment followed by relatively short periods of discontinuous change where strategies, power, structure and systems are fundamentally transformed toward a new basis of alignment.[39]

These changes may be prompted by sudden changes or discontinuities in technologies, in legal or political conditions, in product-life-cycle shifts or internal company dynamics. Tushman *et al.* argue: 'when environments change rapidly frame-breaking change cannot be avoided' and in the private sector, 'recent studies of companies over long periods show that the most successful firms maintain a workable equilibrium for several years (or decades) but are also able to initiate and carry out sharp widespread changes when their environments shift'.[40] In addition executive leadership can be critical to initiation and management of transformational change.[41]

The experience of CSIRO appears broadly to fit this punctuated equilibrium model. CSIRO has undergone extended periods during which its research activities progressively adapt in response to a changing environment. But it has also undergone short periods of substantial, discontinuous change in strategy and operations. In 1978 there was a major shift from fundamental research to applications-oriented research; in 1988 towards technology transfer and user outcomes; in 1996 toward increased customer involvement and ensured industry, government and community users were involved in the planning and monitoring of research programmes; and in 2001 a change in direction toward a primary emphasis on national objectives. In each case there were major disruptions in structure and power distribution, notably in 1988 and 2001.

The recent history of CSIRO suggests that the organisation is unable through its routine internal processes to adjust sufficiently quickly to meet the demands of its environment, and stakeholders, and from time to time requires intervention to achieve this.

The Catalysts of Change

The catalysts that enable change when pressures grow in the external environment may vary. For CSIRO in 1978 and 1988 it was public reviews of CSIRO. The Birch (1977) and Slatyer Reviews (1985) analysed the strategic national context for CSIRO, the need for change, and the measures, including changes in organisational structure, that would give these effects. The reviews were the prompts for action by government and guided amendments to the CSIRO Act. The rationale for change is evident in the public reviews and in statements by relevant ministers.

With the new CSIRO Board the governance responsibilities for CSIRO changed. The trigger for the 1996 restructuring was the Board-commissioned internal review chaired by Dr Frater, which addressed the perceived commercial shortcomings of the organisation and the need for greater focus on research in support of 'identified industry, economic or national benefit sector'.

The triggers for the organisational change in 2001, and the associated rationale are less clear. The changes reflected interactions between the new chief executive Dr Garrett and the CSIRO Board but did not follow a review process, and nor were there public statements by government or CSIRO setting out the rationale for change. On the available evidence, as we have noted, the considerations appear to have been the potentially conflicting objectives of growing external earnings and securing a more clearly defined role for CSIRO in the national innovation system.

Conclusions

CSIRO remains an important part of Australia's innovation system, with a distinguished scientific record and impressive commercial achievements. It has undergone four major strategic reorientations over the past three decades, during a time of continuing economic and social change. Reorientations such as these appear to be the way that a complex and diversified organisation like CSIRO adjusts to a significantly different environment. If so then periodic external public reviews appear the best way to provide focus for CSIRO's role in the national system and to set clear expectations and guidance for its future role.

For more than a decade there has been a curious absence of ministerial guidance as to the government's perception of the role of CSIRO in the modern Australian science and innovation system. It is more than 20 years since there has been an independent assessment of the role of CSIRO, its appropriate position within the Australian innovation system and the suitability of its governance and internal management arrangements. Issues include its relationship with existing and developing industries, in the breadth of its research, and its role in 'public good' versus commercially focused research.

All this points to the case for an independent enquiry into the place of CSIRO in Australia's innovation system and whether or not the recent changes in CSIRO are enough or in the right direction. It is pleasing to see that a review of Australia's national innovation system has been announced by the incoming government.[42]

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