From citadels to clusters: the evolution of regional innovation policies in Australia

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In Australia, the federal (central) and State (regional) governments share constitutional responsibility for aspects of science and innovation policy. In practice, the federal government has tended to overshadow the States both in funding and policy for research and innovation. It can be argued that we are now seeing the strong rebirth of regionalism (at least at the State level) as far as government support for science, technology and knowledge-based industries is concerned. The paper traces the growth of regional innovation policies through examples of initiatives from South Australia and other regions and examines the respective contributions of the State and federal governments. The character of State government support has evolved over the last 15 years, from sponsoring grand 'technology citadels' to today's strategies that take a more bottom-up approach to building intense innovation environments, local clusters and knowledge hubs. Some of these trends reflect the influence of the global knowledge economy on regional industries, while others (notably the relative decline of the federal government as an R&D performer) are peculiarities of the Australian innovation system. The outcome is a significant evolution in Australia's innovation system, one which parallels responses to globalisation in other countries and suggests a different – but not diminished – role for public sector innovation policy.

1. Introduction: Australia's federal innovation system

Over the last century Australia has enjoyed a federal system of government with division of responsibilities between the Commonwealth (federal) government and the six States. Before federation, the constituent colonies had already established scientific facilities and services, universities and technical colleges. Technology policy was also a responsibility of the individual colonies. This led to a lack of standardisation, for example, in the rapidly expanding railway system: Victoria adopted a broader standard-gauge track than did New South Wales (NSW) and South Australia.

The 1901 Constitution ceded to the Commonwealth specific responsibility for functions including telecommunications (postal, telegraphic, telephonic, and other like services), navigation, meteorology and astronomy, and for the regulation of intellectual property rights. Other areas requiring scientific endeavour, notably agriculture and mining, continued as essentially State responsibilities (Tegart, 1991).

Early federal initiatives in science and technology included national research laboratories (both civil and defence) to form what are now the Commonwealth Scientific and Industrial Research Organisation (CSIRO, est. 1949), the Defence Science and Technology Organisation (DSTO, est. 1974) and diverse smaller research

agencies (Garrett-Jones and Liu, 2002). Several of Australia's home-grown high technology companies trace their origin to Commonwealth government enterprises in vaccines, aircraft and telecommunications.

Most Australian universities are autonomous organisations established by State, or in two cases federal, Act of parliament. Significantly, since 1974, the federal government has accepted full financial responsibility for the universities, which prior to 1957 had been largely dependent on State government support. Federal research grants allocated on a competitive basis to academics were introduced earlier, in 1966, and expanded in 1988 with the establishment of the Australian Research Council (ARC). The National Health and Medical Research Council (NHMRC) was set up in 1936 (ASTEC, 1978), becoming a statutory body in 1992.

The States have clear sole or prime responsibility for many aspects of the innovation system, including pre-university education, regional development and infrastructure and, to a degree, industry policy. In the early days of federation the duplication by the Commonwealth of activities that were seen as a State responsibility was viewed with considerable suspicion (Garrett-Jones and Turpin, 1995). Yet in the post-1945 era Australia's public research system came to be dominated by the federal government's research-performing and research-funding agencies. In industry policy too, the Commonwealth has long shaped the overall assistance regime. As the major taxation powers lie with the Commonwealth, the incentives that the States can offer firms are severely limited.[1] States also have limited fiscal influence on their own universities. As Stewart (1991) argues, with the significant exception of agriculture, Australian science and technology has been moulded by the priorities of the federal government.

The current paper suggests that this federal dominance is waning. From the late 1990s, the State governments have become more active in supporting regionally based research, knowledge infrastructure and industry cluster development. In doing so, they have used quite different policy instruments from those attempted in the previous decade. These changes can be traced to a new relationship between the federal and State governments in innovation policy, and to the increasing value placed by regions on their knowledge institutions and businesses as potential players in a global knowledge economy. These trends are remarkably similar to the responses to globalisation reported in countries from North America and Europe.

Recent structural changes in R&D

In his review of Australia's national innovation system in the 1980s, Gregory (1993) identified several distinctive weaknesses: a low level of science and technology expenditure; a high level of government involvement in both funding and undertaking research and of funding the universities; a low level of business R&D; and an exceptionally high dependence on foreign technology. However, the last 15 years have seen significant changes in both the quantum and sectoral balance of national R&D, driven at least in part by explicit government policies and programs.

Australia's gross expenditure on R&D (GERD), expressed as a proportion of GDP, grew steadily from 1.0% in 1981–82, to 1.16% in 1985–86 to reach 1.65% in 1996. Australia is still thus classed as a relatively low R&D investor, ranking fourteenth among OECD nations in 1996. National R&D spending subsequently fell to 1.49% of GDP in 1998, led by a decline in business R&D (ABS, various years).

Over the same period, there was a remarkable change in sectoral contribution to R&D (Figure 1). Business expenditure on R&D (BERD), which was very low at the start of the 1980s (at around 0.25% of GDP), more than tripled to 0.8% of GDP in 1996–97, although it has since fallen to less than 0.7% (ABS, various years). Australia still has a large public research sector (government research agencies and universities), and is ranked fourth among OECD countries in expenditure on R&D in government laboratories. However, federal government funding of its own research agencies has generally declined over the last two decades. Expenditure by the Commonwealth government – the single largest R&D performer in 1981–82 – fell by 28% to around 0.2% of GDP in 1998–99. The greatest decline in federal R&D performance took place between 1986–87 and 1988–89, and since 1992–93. State government performance of R&D has by contrast remained relatively constant over the period, with some increase in the early 1990s. R&D expenditure by the higher education sector (HERD) also grew markedly over the period, particularly since 1988 when a major restructuring and expansion of Australia's universities took place. HERD rose from 0.30% of GDP in 1981 to 0.44% of GDP in 1998.

The structural changes in Australia's R&D over the last two decades can be summarised as

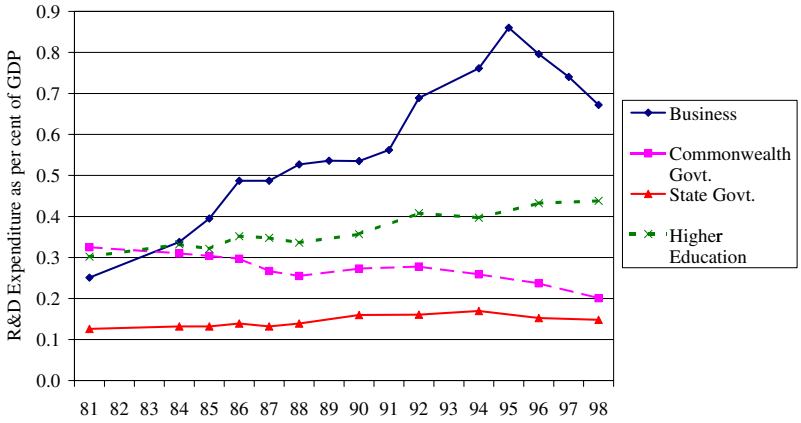

Figure 1. R&D expenditure in the business, government and higher education sectors. Australia, 1981–98.

follows. First, the business sector has grown to become the major player in R&D. Second, R&D collaboration between the sectors is expanding: business funding of university R&D doubled to 5.2% of HERD between 1988 and 1998, while business funding of research in government laboratories increased from 4.8% to 6.3% of expenditure over the same period (ABS, 2001). Third, the higher education sector has now become the major public sector R&D performer. By 1998 universities were spending more on R&D than the federal and State governments research institutes combined.

What this means is that State governments seeking to influence knowledge-based regional development now operate in a completely different environment than they faced in 1982 or 1992. Specifically:

- As a research performer, the Commonwealth government has lost influence overall and by comparison with the State government sector;
- The salience of business and university research implies that States are now more likely to engage directly with these sectors;
- While federal *funding* still dominates public sector R&D, this is likely to be felt through its influence on university research rather than through CSIRO and other Commonwealth research agencies;
- The growth of business R&D spending means that local firms and industries are commanding a stronger say in regional innovation policies.

R&D in Australia's regions

Australia's population and economic activity are strongly concentrated in the two south-eastern States of Victoria and NSW (which together contributed 58% of GDP in 1996). Table 1 shows state/territory R&D expenditure in 1998, both in total (GERD) and for the business sector (BERD). In all the States and the Northern Territory, total R&D expenditure fell between 1.2% and 1.9% of GDP. The exception is the Australian Capital Territory (ACT) where, despite a weak manufacturing base, the concentration in Canberra of several major universities and research agencies are reflected in a higher 'territory GERD'. Greater regional variation is seen in business R&D spending. BERD in the larger States stood at between 0.6% and 1.0% of regional GDP in 1998, with the exception of Queensland where it was lower at around 0.45% of GDP. In Tasmania and the two internal territories, business R&D expenditure was less than half the Australian average. The local composition of industry has an influence. In Western Australia, the proportional decline in BERD between 1996 and 1998 is in large part due to a downturn in the minerals industry.

2. Regional clusters and innovation policy

Industrial innovation clusters arise where there is a loose geographic concentration or association of firms and other organisations involved in a value chain producing goods and services and innovating. The literature on regional innovation clusters is extensive both in theory and in empirical studies (Acs, 2000; Holbrook and Wolfe, 2002), and draws upon concepts from economic geography, industry supply chains and the innovation systems approach (Nelson, 1993).

Table 1. Regional GDP, population and R&D expenditure in Australia's States and territories, 1996 and 1998.

	GDP (US$ million) 1996	Population ('000.) 1996	GDP (US$) per capita 1996	GERD (US$ million) 1996	GERD % of GDP 1996	GERD % of GDP 1998	GERD US$/000 pop. 1996	BERD (US$million) 1996	BERD % of GDP 1996	BERD % of GDP 1998	BERD US$/000 Pop. 1996
AUSTRALIA	395,790	18,309	21,617	6,798	1.70	1.49	371,293	3,135	0.74	0.67	171,227
New South Wales	134,777	6,204	21,724	2,034	1.51	1.25	327,853	1,125	0.83	0.62	181,335
Victoria	103,498	4,561	22,692	1,925	1.86	1.72	422,057	1,100	1.06	0.95	241,175
Queensland	65,433	3,339	19,597	884	1.35	1.22	264,750	336	0.51	0.45	100,629
Western Australia	44,915	1,766	25,433	689	1.53	1.30	390,147	381	0.85	0.68	215,742
South Australia	27,414	1,474	18,598	493	1.80	1.87	334,464	154	0.56	0.59	104,478
Australian Capital Territory	7,589	308	24,640	474	6.25	4.39	1,538,961	21	0.28	0.26	68,182
Tasmania	7,776	475	16,371	156	2.00	1.66	328,421	45	0.58	0.35	94,737
Northern Territory*	4,389	182	24,115	56	1.27	1.22	307,692	13	0.30	0.26	71,429

Source: After Minchin (2000) Table 11 and DISR (2001). Note:*NT data are for 1997 and 1998.

Michael Porter (1990) describes formal cooperative linkages among firms, and between firms and technology organisations that lead to business clusters that are globally competitive. The innovation cluster concept goes beyond the traditional ideas on industry clusters, which involve horizontal networks of firms operating on the same product market in the same industry sector. It stresses the advantages of close proximity between producers, suppliers and support services in diverse industries. Thus, innovation clusters are cross-sectoral, involving dissimilar firms that collaborate with each other and with public knowledge institutions such as universities and research laboratories. While Porter and others point to the agglomeration of technical skills, specialist services, infrastructure, proximity to universities and knowledge spillovers within innovating clusters, it is also clear that, as Saxenian (1994) notes, spatial proximity by itself reveals little about the success of clusters. Several authors have identified the significance of the social capital generated within the complex relationships of regional networks, structures and institutions. Saxenian (1994) uses this network perspective thesis to explain the different histories of Boston's 'Route 128' and California's successful Silicon Valley (where firms and organisations were more porous and interrelated). Where clusters have developed the financial, learning and productive cultures and knowledge networks sufficient to facilitate systemic innovation, they can be regarded as constituting a regional (or regionalised) innovation system (Cooke and Morgan, 1998) or learning region (Cooke and Morgan, 1998; Florida, 2000).

Studies of regional innovation from Europe (Cooke *et al.*, 1997) and North America (Saxenian, 1994; Holbrook and Wolfe, 2002) provide evidence both for strong common responses to globalisation and growing knowledge-intensification of industries, as well as for the influence of unique local factors.

In noting the greater attention being given to the regional dimension of innovation policy in Europe, Cooke (2000) suggests several drivers. The first of these is the erosion of the power of national governments by globalisation, but also by supranational authorities (notably the European Union). Cooke further suggests that national governments are most constrained in their support for large firms, hence their support for SMEs. The second also relates to globalisation and its effect on regions. Cooke provides evidence of increasing geographical specialisation

and concentration as a result of globalisation and suggest that transnational companies are seeing advantage in embedding in these regional skills and supply chains – although the availability of incentives from regional governments must also be taken into account. As Varga (2000) notes (in relation to the USA), 'in the global economy, modern regions are far less subject to changing national policies'.

The concept of the regional innovation system is clearly an extension of the 'national innovation system' model of Nelson (1993) and others. But it is also a reflection of what Acs *et al.* call the 'dispersive revolution' – a balkanisation of national economies and massive devolution in the governance of business and public sector organisations and concurrent dissolution in governance systems, leading to the reinforcement of community bonds (Acs *et al.*, 2000). Thus, 'the opposition between local and national systems of innovation is rooted in the contrast between two dynamics: the bottom-up dynamics of networks and the top-down dynamics built on the centralized mind-set' (Acs *et al.*, 2000, p. 40) – essentially the clusters and citadels of the current paper.

The literature provides evidence of a shift in the balance of power towards regional governance in the USA, Canada and Europe akin to that seen in Australia. But if power is moving to the regions, what government incentives and policy instruments are likely to be effective at the regional level? Here the international literature is less unanimous. Perhaps, as Florida (2000,p. 231) contends, the problem is a lack of knowledge: 'the role of regions in the new age of knowledge-based global capitalism remains rather poorly understood'. Equally likely, it is a lack of experience. For example, in several documented cases, universities have been major agents of regional economic growth. But as Varga (2000) points out, we have only a limited understanding of *how* to replicate this success elsewhere: it appears to depend on the level of development of the local innovation system as well as the characteristics of the university. On the other hand, the literature provides extensive lists of desiderata for learning regions (for example see Cooke *et al.*, 1997). Studies from Europe (Laredo and Mustar, 2001, n.d.) suggest that support for the university environment ('acting on the higher education landscape') and measures targeted specifically at enhancing the innovation capabilities of SMEs are, first, important for building knowledge-intensive industries and, second, particularly open to influence by regional governments.

The elements of regional innovation policy are surely emerging: support for business, social and professional networks and for the knowledge infrastructure (including universities), for intermediary technology transfer and training agencies, as well as incentives for individual firms. Thus several of the trends seen in public policy in Australia – devolution, the emphasis on linkage with knowledge institutions – appear to reflect other countries' experience of the local face of globalisation. Less evident in Australia, as the following discussion shows, is construction of the wider social capital building networks and organisations at a local level.

3. Policies for regional research and innovation in Australia

In his review of the South Australian Industry Clusters program, Richard Blandy makes the following observation:

> Winning frameworks in the modern world are not citadels but webs. Command-and-control goes hand-in-hand with failing citadel structures. Collaborative networks provide the structure for successful webs (Blandy, 2001).

We use Blandy's metaphor elsewhere to describe the development of regional innovation policy in South Australia as evolving from citadels into clusters (Burns and Garrett-Jones, 2002). The current paper explores the degree to which the trend of regional innovation policies in Australia over the last 20 years can be described in the same terms. The citadel model in this context is used to label initiatives that are self-contained, top down, often large, and frequently in competition with each other. The web/network, or by extension cluster, model describes those policies that have the effect of promoting collaborative networks, generated from the bottom up, which may start small, and which increasingly have a perspective of regional integration.

The observations in this paper are based upon studies of innovation clusters and policies in four regions of Australia: Adelaide (SA), Melbourne (Vic.) and the Illawarra region (NSW) (Turpin *et al.*, 2002a) and Western Australia (Turpin *et al.*, 2002b), and on a review of historical and current trends in science and innovation policy at the state and federal level (Garrett-Jones and Liu, 2002).

Commonwealth and State policies for support of science and innovation in recent years have both influenced and have had to take account of the more pluralistic research and innovation system that has emerged in Australia. A range of policies has been employed, including:

- Incentives for private businesses to undertake R&D and innovation, including tax concessions, research grants, information and extension services, provision of venture capital and training measures;
- Measures aimed at commercialising public sector research in the civil, health and defence areas, involving earnings requirements for government research agencies, facilitation of joint ventures;
- Programs to promote cross-sectoral collaborative research between university-industry-government laboratories;
- Policies aimed at encouraging R&D and innovation in specific industry sectors, including policies aimed at transnational corporations;
- Support for research or innovation infrastructure such as major research facilities and technology parks;
- The establishment of dedicated organisations and strategies to implement and coordinate science and innovation.

A recent inventory of government programs providing support for innovation in firms lists around 83 separate schemes at the Commonwealth level, and a further 136 support programs at the State/Territory level (Jones and Wood, 2001). In addition, there are many programs that provide funding for research and training activities in the public sector.

Federal government policies

Table 2 shows the largest federal government schemes that currently support innovation. Many are relatively new: only 8 of the 21 existed in a comparable form in 1990. None of the established schemes is specifically regional in design, but several (R&D Corporations, automotive schemes) certainly benefit particular regions. Two newer schemes do support regional innovation: the BITS program for IT incubators, and specific incentives (through ARC) for universities outside the capital cities to undertake research of benefit to rural and regional communities (Kemp, 1999).

There is increasingly policy emphasis on *networked* research and innovation activities. A critically important development, from the early 1980s but accelerating in the 1990s, has been federal government support for various forms of cross-sectoral collaborative R&D, training and technology development. University-industry alliances in particular have been stimulated and funded by a continuum of government programs that have evolved significantly over at least 15 years, and show a trend towards formalised and structured arrangements for managing cooperation (Turpin *et al*., 1996). The Cooperative Research Centres (CRCs) are the major example in Australia of new organisational forms that rely on the integration of research, teaching/training and technical cooperation. First funded in 1991, CRCs are distributed research centres that unite participants from the universities, government sector (State and federal) and businesses for long-term, contractually agreed research and education activities. Of the longer established schemes, the 'R&D Corporation' model has been effective in bringing together industry and research experts to fund research and technology transfer in a range of agricultural, food processing and environmental areas. The ARC's Linkages program is the expanded successor to a range of collaborative research grants, scholarship and fellowship schemes that have been highly successful in engendering R&D and training links between universities and industry (Turpin *et al*., 1999).

State government policies

State government programs appropriately take a more grass roots approach than the Commonwealth programs. Increasingly, they are aimed at building up innovation clusters and in supporting the regional knowledge base, particularly in the universities (Turpin *et al*., 2002b). The move to a more cluster/web approach in recent years can be seen in the way that States have dealt with innovation organisations and strategies, with research grants, skills policies, venture capital and investment, and technology parks and zones.

Organisations. Most States and territories of Australia have established dedicated strategies and organisational structures for research and innovation. Government departments or agencies designed to promote the development of knowledge-based and advanced technology industries had been created in all States by the mid 1980s. From the early 1980s a series of state-level

Table 2. Major Australian federal government programs supporting innovation in firms, 2001.

Program	Purpose and type of support	Est. annual expenditure (A$ million)
R&D Start*	Grants and loans for R&D projects, graduate research collaboration grants, technology commercialisation grants for small companies.	200
Tax Concession for Research and Development*	125 per cent tax deduction for eligible R&D expenditure.	About 400 in revenue foregone
Innovation Investment Fund (IIF)	Equity capital for small, new technology firms.	17
Pre-seed Fund	Funding for universities and public sector agencies to take research outcomes to venture capital stage.	15.8
Commercialising Emerging Technologies (COMET)	Business advice and management assistance.	10
Cooperative Research Centres (CRCs)	Grants to support cross-sectoral R&D collaboration in large distributed research centres.	145
Major National Research Facilities (MNRF)	Funding for expensive, large equipment items and specialised laboratories; access to such facilities.	30
Technology Diffusion Program (TDP)	International technology alliances; domestic technology diffusion projects	25.5
Automotive Competitiveness and Investment Scheme (ACIS)*	Import duty credits based on investment in R&D and plant and equipment.	400
Shipbuilding Innovation Scheme (SIS)	Subsidy of up to half of eligible R&D costs.	10.3
Textile, Clothing and Footwear Strategic Investment Program (TCF SIP)*	Grants to foster investment, R&D and innovative product development.	140
Innovation Access Program	Access by Australian researchers and firms to global research and technologies.	20
Pharmaceutical Industry Investment Program (PIIP)*	Higher prices on nominated products in return for undertakings on, inter alia, R&D.	60
Biotechnology Innovation Fund (BIF)	Support for biotechnology start-up companies.	13.3
Renewable Energy Commercialisation Program (RECP)	Support for post-R&D commercialisation and industry development.	11.5
Australian Research Council Linkage Program: Project and Infrastructure Grants*	Collaborative projects between higher education researchers and industry; projects of benefit to regional and rural communities; research infrastructure for joint use by universities, research organisations and industry.	82
Rural industry and environmental Research and Development Corporations* (including industry levy funds)	14 sector or commodity based corporations supporting R&D and technology transfer.	300
Building on IT Strengths (BITS)	IT incubators in each state and territory to foster R&D and commercialisation ('Intelligent Island' program in Tasmania). Development and demonstration of advanced networks.	31.6
Information and Communications Technology (ICT) Centre of Excellence (awarded in 2002)	To establish a stand-alone ICT institute.	26
Partnerships for Development Program (PfD)*	Agreements with major international IT and telecommunications companies on R&D and investment activities in Australia.	-
Defence Capability and Technology Demonstrator (CTD) Program	Demonstration of leading edge defence technologies.	20

Note: Only programs with expenditure of more than A$10 million per annum are listed. *Programs that existed in a substantially similar form in 1990. *Source:* Jones and Wood (2001).

advisory councils on science and technology were established. These included the South Australian Council on Technological Change, which was the first; the West Australian Technology and Industry Advisory Council; the NSW Science and Technology Council and the Queensland Science and Technology Council (ASTEC, 1991). Victoria established a Strategic Industry Research Foundation (SIRF) in 1988 in partnership with the Australian Academy of Technological Sciences and CSIRO. SIRF was involved in many strategic research ventures in biotechnology, energy and the automotive industry.

Most of these first generation advisory and commercialisation agencies have not survived the turn of the century without significant change. The Victorian government wound up the SIRF in 2000, for example. In NSW and Victoria, the departments of State Development are now responsible for S&T and innovation matters. A new South Australian Innovation, Science and Technology Council was established during 2000, and Victoria has a new advisory Knowledge, Innovation, Science and Technology Council. State governments have also set up sectoral technology advisory councils notably for biotechnology (NSW, WA, Queensland) and information technology. Victoria has appointed an 'ambassador for biotechnology' and announced a biotechnology strategic plan. Victoria's information technology and multimedia policy, Victoria 21, was released in 1996. The smaller States have developed broad Science and Technology Policy documents (WA in 1997 and Tasmania in 2001) or Innovation Strategies (Queensland), while South Australia plans to introduce an R&D and innovation index for the state.

R&D Grants. Most States have also provided grants for R&D projects, often with an industry collaborative component. The Western Australian R&D (WARD) grants were an early example. Nowadays, state R&D grants tend to complement and supplement the federal research grant schemes. Several States have provided grants in support of CRCs, or of CRC proposals (Victoria's CRC Support Program; the Australian Capital Territory R&D grants scheme; and in South Australia). Funding for prominent research groups also comes from the Centres of Excellence (WA) and Tasmanian Icons Program. Grants and strategies are also aimed at providing research and innovation infrastructure, some again leveraging Commonwealth funding. A recent Victorian initiative is the Science, Technology and Innovation Initiative Competitive Grants for Infrastructure Program. The development of a consortium proposal for a synchrotron facility in Queensland is an example of state facilitation of bids for major national research facilities to be funded by the federal government.

Skills development. State government has direct responsibility for primary, secondary and some tertiary education, and a close relationship with local universities. It is not surprising therefore that scholarships and related educational and skills development strategies are prominent in state policy for research and innovation. Recent examples include scholarships for postgraduate study in information technology in Victorian universities, and a Victoria Schools Innovation Commission to oversee the development of information and other technologies in schools. An information and communication technologies skills strategy in Victoria includes a rotating 'Think Bank' of experts to recommend to the government new alliances for incubation and innovation. New South Wales has also promulgated an action plan to overcome shortages of skills in the information technology and communication fields. The plan includes an IT Corridors Development Program that links measures in urban planning, industry incentives and educational infrastructure.

Venture capital and investment. In the 1980s, several States created government owned and managed investment agencies with the intention of providing venture capital to new technology enterprises and innovating firms (Ryan, 1991). These included Development Corporations in Queensland, Victoria, Western Australia and Tasmania. New South Wales and Victoria provided finance through their Investment Corporations. The Victorian Economic Development Corporation (VEDC), for example, had a mandate to 'operate on commercial lines whilst taking more risk than would be acceptable to conventional financial institutions' (Eisen, 1991, p. 70). The government instructed VEDC to target preferred industries, including those in 'trade exposed' and export industries. Funding in 1987–88 was specifically targeted at priority areas including professional and scientific equipment; food processing; horticultural products; biotechnology; information technology; and advanced materials (Eisen, 1991, p. 70).

These investment agencies did not survive into the 1990s, in one case because of poor performance but largely because of changes in the political climate. The VEDC was abolished after incurring massive losses, the NSW Investment

Corporation was privatised, and the profitable West Australian Development Corporation was scrapped. Current state initiatives are limited to grants or loans for innovation or commercialisation of technology in firms (WA, Tasmania); and support for showcasing technologies in various ways. For example, Queensland has announced a Biostart Program of grants for start-up biotechnology companies in the state, while Technology Direct is an Internet access point for Victorian technologies.

Technology parks. A further initiative by South Australia led to the establishment in 1981 of Australia's first technology park in Adelaide. From the 1980s, technology incubators and S&T parks proliferated under the State governments and there are now around 17 in operation. As Roberts (1996) notes, these developments tended to follow the British science park model, centred on a university and/or other public sector research institute. The intention was two-fold: first to encourage the public sector research institutions to contribute more strongly to industrial development and, second, as an attempt on the part of the State governments 'to use the highly regarded universities as a bait to lure the business sector into performing and investing in R&D' (Roberts, 1996, p. 223). To an extent, 'in the 1980s the stimulation of high technology industry became a part of competition between the States in bidding for industry location, along with government funding and contracts' (Roberts, 1996, p. 225).

The federal government became involved in 1987 when Japan's Ministry of International Trade and Industry (MITI) proposed a joint 'city of the future' in Australia. This Multifunction Polis (MFP) was presented as an incubator for high tech industries – like biotechnology, new materials, rare metals and software – and for 'high touch' services like conventions, health care and education. In 1996, after lengthy negotiation with the South Australian and Japanese governments, the federal government ceased funding the project.

The development of Australian technology parks occurred in a period where State governments were prepared to invest heavily in tangible technology initiatives. Few new parks were established during the 1990s, although most of the existing parks survived. The Australian Technology Park (ATP) in Sydney was a latecomer that has continued to develop with core funding from the federal and NSW State governments. State governments are continuing to fund technology parks and incubators on a smaller scale. The Victorian government has provided regional infrastructure development funds for an Information Cluster Development Centre at Ballarat. Victoria sponsors feasibility studies for technology parks, business incubators and training for park managers. A Technology Precinct is being developed to complement the Bentley Technology Park (WA) and Queensland's recent initiative is an 'i-lab' technology incubator for start up companies.

These qualitative changes towards more knowledge web- and cluster-oriented programs are summarised in Table 3.

The emergence of cluster policies in South Australia

In South Australia, for example, the ultimate collapse of the citadel MFP technopole spawned a new approach to innovation policy: local cluster development (Burns and Garrett-Jones, 2002; Enright and Roberts, 2001). The clusters policy began within the MFP in 1995. The cluster team moved, via the Department of Industry and Trade (DIT), to the South Australian Business Vision 2010 (SABV 2010) in 1998. SABV 2010 was formed in 1996 by the South Australia Employers' Chambers of Commerce and Industry. Its significance was in distancing the cluster program from a large government department and locating it in the domain of industry. The State government remained involved by contributing modest funding (Blandy, 2001).

In the short life of the clusters program within the MFP and DIT two clusters were developed, those of defence and multimedia. To these were added spatial information and water, each derived from different government initiatives, the first from implementation of the IT2000 program and the second, water, following privatisation of that industry. Others added by SABV 2010 included a sport and recreation cluster, international tourism, mining and geosciences, and a cluster for the Upper Spencer Gulf region. Nine clusters were begun, seven have survived and three are newly established.

The industry driven clusters program of SABV 2010 has government sponsorship. However, its philosophy and genesis is from an American model, namely the Joint Venture Silicon Valley Network that carries a much stronger perception of the *social* dimension of clusters (business leadership, municipal governance, community strategy) than seen previously in Australia.

Table 3. Examples of changes in State government innovation programs from the early 1980s to the late 1990s.

Policy and program area	'Citadel' model (early 1980s to mid 1990s)	Cluster/web model (emerging from mid 1990s)
Organisation and strategy	Unitary science and/or technology councils with advisory role, little or no leverage funds. No broadly based innovation strategy for the State. Technology driven priorities	Sectoral technology councils, often with funds to spend in support of projects etc. Support for 'arms length' community-based intermediary bodies like SA Business Vision 2010. State technology strategies based on consultation; regional and sectoral strategies. Priorities emerge from local concerns (water, tourism) as well as critical technologies.
Funding: grants for R&D; venture capital etc	'Monolithic' venture capital, investment or 'commercialisation' corporations. Some small stand-alone R&D grants.	Modest grants for technology based start up companies (e.g. biotech) Larger R&D grants matching federal funds in many cases (e.g. CRC or major facilities). Direct funding for academic centres of excellence.
Skills development	Various, but not well linked to broader innovation programs and strategies.	Strategies linked to industry incubation and innovation networks (e.g. IT Corridors Development program) Targeted university research scholarships (e.g. IT) Education programs linked to technology strategies
Infrastructure investment	Focus on direct investment in large tangible infrastructure projects (technology parks, MFP technopole etc.) rather than on knowledge or information networks.	Grants for academic research infrastructure. Small incubation centres and support services. Information technology corridors, and information clusters linked to industry or universities.
Relation with federal policies	Virtually no regional element to federal innovation programs. With some exceptions (agriculture, industry extension) weak articulation between federal and state programs. Increasing federal support for industry collaborative R&D structures later in the period.	Growing regional element in federal innovation programs (ARC regional linkage grants, BITS). Increased leveraging of federal programs by States, in tandem with 'go it alone' initiatives.

4. The evolution of regional innovation policies in Australia

Four main characteristics of recent State government policies and initiatives can be identified. First, they have become *less 'compartmentalised'*. While it is an oversimplification to see the State policies of the 1980s and early 1990s as comprising only S&T councils, technology parks and investment capital, the initiatives of the last few years are far broader in scope. They are less inclined to favour major, high visibility citadels like the MFP. They encompass education and skills programs, public and industry awareness campaigns, commercialisation initiatives and support for innovation infrastructure in the broadest sense. Innovation and knowledge generation (including academic science and research) have moved onto centre stage in policy terms. They have become central to – and thus integrated with – the economic and social planning of many States, as evidenced by their state innovation strategy documents. Innovation policy is informing, and being informed by, regional planning.

Second, regional policy instruments have become *more specialised*. New bodies and strategies tend to be industry, problem or technology focused – no single agency is expected to cover all fields of endeavour. States are also concentrating on their regional strengths, rather than all chasing the same suite of high-tech industries. Thus we see, for example, a Queensland Agency for Food and Fibre Sciences, and a Western Australian Strategic Research Fund for the Marine Environment.

Third, policies have become more *connected* and more *partnership* oriented. The membership of the South Australian Innovation, Science and Technology Council, for example, comprises business executives, CRC directors, research agency heads, and senior academics. But perhaps the key emerging feature is the support offered for bottom-up clustering of all sorts, especially that which engages industry and knowledge institutions like universities.

Fourth, a renewed aspect of this connectedness is the relationship with the federal agencies. Many State initiatives deliberately ride upon Commonwealth government programs and funding. The CRCs are an example of a wholly federal government initiative that has been embraced by the States as an effective catalyst for developing knowledge based linkages. Competition has not wholly given way to collaboration. In Queensland, there is a perception that the State is not gaining a fair share of Commonwealth R&D funds, despite contributing strongly to funding CRCs within the State. Another example is the contest during 2001 between Queensland and Victoria for federal funding for a major national research synchrotron facility.

Implications for the management of research and innovation

If sustained, the finding that the locus of power of innovation organisation and policy is moving towards the regions has wide implications for firms, research and community organisations and governments in Australia. State (and even local) governments are becoming more closely involved in initiating support programs for firms and the local technological community, and/or delivering programs in cooperation with federal agencies. Further, the collaborative model of R&D sustained through the Cooperative Research Centres program is now being embraced for larger technology centres and for direct cooperation between state governments. This represents an extension of the activity of state governments and involves experiment in administration, at both program and organisational levels, the impacts and effectiveness of which will need to be assessed.

For the federal government too, a more cooperative approach to supporting R&D and industrial innovation is emerging. The Commonwealth government has started to consider special funding for Australia's regional (non-metropolitan) universities to support their role in locally based innovation, but this has taken place in the context of pressure for increased self-funding in higher education.

Management of public R&D in Australia is thus moving in halting steps away from the top-down citadel model and towards a range of bottom-up networks, cooperative arrangements and local clusters. The structural models being used are primarily those derived from cooperative R&D. But Australia has yet to emulate the strong trend seen overseas for the creation and sustenance of what may be termed 'community innovation organisations' and networks (like Silicon Valley's JVSV network and Canada's Ottawa Centre for Research and Innovation – OCRI) which are locally based and which have a mandate to link firms, training, research, government and business groups for the purpose of local development and welfare.

For firms in Australia's cities and regions, the challenge of confronting a wider range of R&D players and government programs is greater than ever. This diversity of choice implies a need for clear strategies for collaboration at the firm level. Effective informal interaction of individual firms through business and community networks and intermediary organisations would seem to be a necessary precursor to such business planning.

5. Conclusions

We are now seeing the strong rebirth of regionalism (at least at the State level) as far as government support for science, technology and knowledge-based industries in Australia is concerned. Public policy has evolved over the last 20 years to sustain, initially, collaborative R&D and innovation networks and, more recently, regional industry and knowledge clusters. The focus on regional development is not new, but the strong emphasis on knowledge infrastructure and knowledge clusters is. To a large degree, these trends parallel those seen in other federal countries and in the European Union.

But are the factors driving these changes are predominantly domestic or predominantly global, or do they result from an intersection of the two? Clearly, global influences are very important. Australians can no longer count on traditional low value-added exports to sustain their high standard of living. The global dimension of many industries and the prevalence of new communication technologies have relieved the requirement for a geographic critical mass in research, production or technology markets. In turn, this has created opportunities for businesses in the Australian regions, which in the past had been constrained by their small domestic or regional market and limited access to technological know how.

On the domestic front, the concentration of economic power, social infrastructure, research and innovation in the two most populous States of Victoria and NSW and, within these States, in the major metropolitan areas, remains a disadvantage for many rural regions. The relative decline of the Commonwealth government as an R&D performer is a further domestic factor driving increased collaboration and networking across research sectors and regions. Federal domination of university funding and local issues such as the privatisation of State water utilities are also factors.

The process of globalisation, however, means that the potential for public policy to promote and capture benefit from innovation is increasingly problematic. In pursuing their goals, Australian States are using policy tools similar to those found in the European and North American context, even though, unlike the European situation, there is no corresponding supranational agency with a brief for regional development. But as Laredo and Mustar (n.d.) comment, 'we lack a global analysis on the variety of policies this movement entails and on the ways regions have progressively shaped their interventions'. More empirical study is required for a better understanding of the dynamics operating in the local, national and supranational policy domains, but evidence so far suggests not a diminished role for government in innovation policy, but rather a different role.

Australia's federal system of government should allow these concerns to be addressed successfully at the regional level. Nevertheless, many challenges remain in harnessing innovation and technology policy for regional development. There may be need for a new accommodation between federal, state and local levels of government. Should federal government, for example, give more support to regional development based on knowledge clusters? How can State governments influence the behaviour of their local universities when the federal government controls the higher education purse-strings? A further issue is the engagement of fragmented municipal governments. Despite examples of community driven industry cluster formation (Enright and Roberts, 2001) there is very little formal interest in technology development at this level of government. The notable exceptions are the city States of South Australia (Adelaide) and, within it, cities such as Playford, and the ACT (Canberra). Further, state and territory boundaries can act as a barrier to inter-state regional development unless the Commonwealth is prepared to take on a facilitating role.

Finally, policies that aim to develop regional, knowledge-based economies in Australia will need to take greater account of regional strengths and of the capacity and aspirations of local and regional communities. Those intermediary structures that appear to be effective for building knowledge-based clusters (e.g. JVSV and OCRI) are novel, even alien to Australia. Their adoption presents challenges for cooperative support and financing involving government, business and communities at all levels. Public support for

bottom up regional community initiatives for knowledge clusters may involve new organisational models that avoid command-and-control by putting government at arms length.

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Note

1. The balance of taxation (80%) in Australia is overwhelmingly with the Commonwealth (largely income tax and goods and services tax – although the latter is returned to the States) rather than with the States (20%, largely property and payroll taxes).

