No. 40

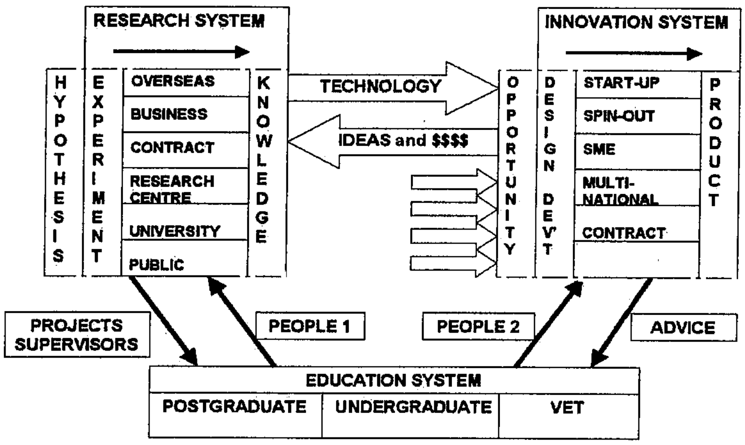
Pathways to Technological Innovation

A Submission to the Standing Committee on Science and Innovation

Professor Trevor Cole

I respond to the seeking submissions concerning issues relating to successful innovation within the Australian context. I do this in my capacity as member of the Electronics Industry Action Agenda Implementation Group (in which I chair the Industry Development working group) and drawing on my other, wider involvements in innovation matters over many years as evidenced in the brief CV annexed below.

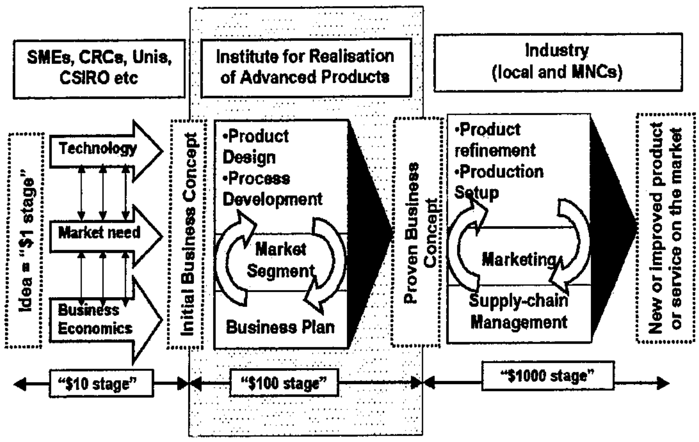
At the core of appreciation of successful innovation in Australia is to overcome the blurring, in Australia of the distinction between its research system and an effective innovation system. I draw a clear distinction between them. The research system produces knowledge. Only **useful** knowledge (technology) is of value as **one** possible input to innovation. It is **only** innovation that uses research, **design** and **development** to produce products, services or processes of economic or community value.



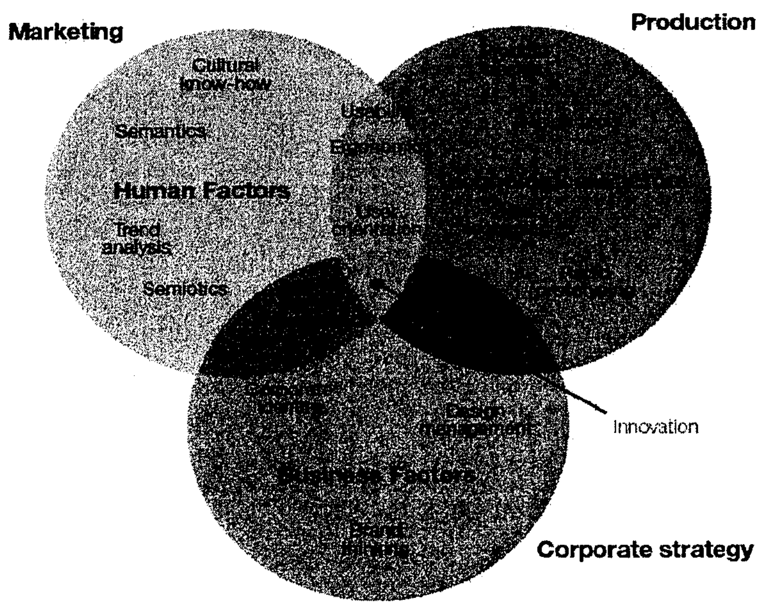
Whereas Australia's public sector research is predominantly basic and strategic in its focus, any aspiration to large-scale contribution to economic benefit requires a shorter time scale (hence applied research and experimental development) and a much greater matching between any useful knowledge produced and Australia's industrial capacity to absorb it. Significantly, the economic benefit will be achieved by technologists and engineers rather than scientists and more often than not by integration of existing knowledge in new ways rather than through radical innovation. (The list of Action Agendas exemplifies this - accounting for about a third of Australia's gross domestic product (GDP) and employment, about 60 per cent to Australia's export earnings and over 75 per cent of Australia's business investment in R&D.)

A major conclusion of the Electronics Industry Action Agenda working group has been that Australia's greatest weakness in innovation continues to be at the phase of converting an initial business concept into a proven business concept demonstrated by an industrially-relevant, pre-production prototype of the product or service. To that end it has focused in detail on the need for a major national focus on this through an "institute for realisation of advanced products". Many of such products and services (but not all) will use electronics and ICT as the key enabling technology in which to embody the innovation.

Realising advanced products relies on "innovation technologies" – the very sophisticated computer-based tools and prototyping facilities now available and the high bandwidth networks needed for collaborative "open innovation" and remote access to such tools. In addition, the stages of technical risk reduction in which the early prototypes are assessed for standards compliance or studied for failure modes are what makes the very significant future costs of manufacture and marketing of any prototype justifiable.



Success in this product realization phase relies on skills radically different from the science of research. As a minimum it is technologists and engineers who integrate the technology (often existing) into the unique market-related product or service. It is mastery of the process of product design and its management which is core but which is almost completely lacking from the tertiary education of engineers in Australia. Even more importantly, design is hardly ever presented as an integrated process where innovation occurs at the intersection of human factors, business factors and technology factors amongst cross-discipline teams. This is well represented by a key diagram from the major Tekes project on design in Finland:



Integrating understanding of the product development process with the development of skills in technology entrepreneurship provides the other missing leg to a more effective innovation system in Australia. It is the entrepreneur who will use mastery of the innovation and product development processes to access the resources needed to convert a market-related opportunity into a successful product or service – acquiring the technology from wherever appropriate, be it overseas, existing capabilities or, occasionally, original Australian research.

Brief comments are provided below on a number of the issues identified in the terms of reference.

Pathways to commercialisation

It is poorly understood in Australia that direct spin-out of a technology-based company incorporating public sector research IP can only ever be a very minor part of technology-based innovation activity. In the cluster around Cambridge in the UK, Gothenburg in Sweden and here at the ATP, such university-linked companies are less than 10% of the overall start-up activity.

The vast bulk of the growth of activity is from **indirect** start-ups where the key ingredient is the relevant higher education skills of the key founders utilizing their own skills and knowledge to integrate technology into a market-identified opportunity. Also identified as very important in the case of Cambridge is the handfull of serial entrepreneurs who have done much in their own right and through stimulation to encourage new venture creation.

The conclusion is that providing relevant skills and attitudes amongst the graduates – especially first degree graduates – will develop the pool of those who will grow technology-based clusters. It is not often that the PhD or academic is the key driver of high-growth, technology-based businesses.

Intellectual property and patents

It is increasingly understood that university ownership and exploitation of IP will not be a major revenue generator for universities. An interesting contrast is in Scandinavia where the researcher retains ownership. This has generated greater commitment to exploit and a good example exists at Chalmers University in Gothenburg where this has enabled strong involvement of masters students as the commercializing pathway for that IP.

Skills and business knowledge

Having developed and delivered programs in technology entrepreneurship to both undergraduate and postgraduate students, it is clear that strong student interest exists. However, university structures and attitudes make it very difficult to establish a distinct focal point and resource to sustain such activity.

Internationally, others have been much more strategic and supportive. In Scotland the Scottish Institute for Enterprise supports and co-ordinates entrepreneurship activities across 13 universities in Scotland. Within England, the Higher Education Innovation Fund (HEIF) exists as a third stream of funding, alongside research and learning/teaching. A total of £171 million has been awarded over 2004-05/2005-06. Resources can be used for knowledge transfer, entrepreneurship training, corporate spin-outs, seed venture funding and transferring knowledge into business and the community.*('Investing in innovation: A strategy for science, engineering and technology', DTI, DfES, HM Treasury, July 2002)*

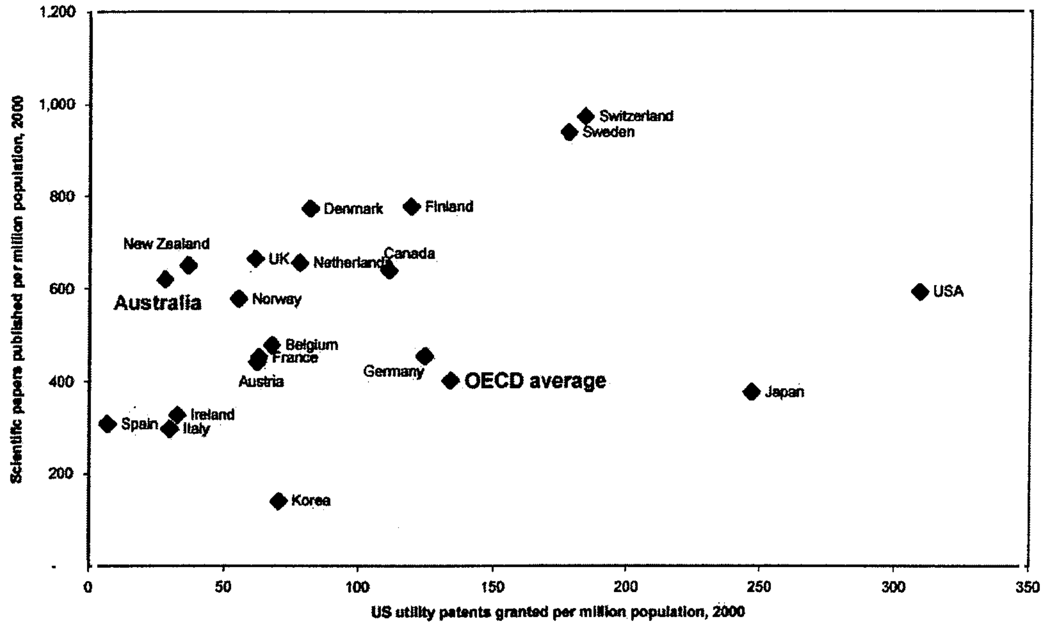
Specifically targeted funding such as in HEIF is perhaps the only way to ensure that resources are not dissipated within traditional university internal funding arrangements.

It is of note that Macquarie University in Sydney has made a commitment through a newly established Institute for Innovation to “create a culture of enterprise” across the entire university.

Research and market linkages

A good indicator of the mismatch between research in Australia and market relevance is the following figure (Mapping Australian Science and Innovation, page 73):

Figure 2.20: A snapshot of Australia’s performance in science and innovation



Source: OECD (2002g), p 317; and USPTO (2002), p A1–1.

Market relevance of the knowledge being produced in Australia is abysmally low - enhanced by other weaknesses in research focus relative to market opportunity.

Another relevant statement from that report is the footnote to a figure of Commonwealth support to business R&D (Figure 5.34, page 385): *“Note: Data displayed on a logarithmic scale due to R&D support being an order of magnitude greater than commercialisation support”.*

Because they have not received the coverage they should, the following statements from that report are repeated:

- *Australia’s high-tech exports are less than a third of its imports and Australia 26th of OECD for high tech exports as proportion of GDP (page 12)*
- *Australia’s manufacturing sector mostly companies with R&D intensity of less than 4% cf Germany and Sweden where more than half manufacturing sector is companies with R&D intensity greater than 5% (page 13)*
- *A critical and persistent weakness is the low level of investment in public sector ICT R&D, which is estimated to be about 30-50% of levels in the EU and Japan (pages 14 and 307)*
- *The R&D base for ICT will remain small by international standards, which may have effects in the future on the ability to commercialise research findings, the availability of high-quality ICT researchers and the supply of key skills for the information economy (page 14)*

- *Key finding 11: Notwithstanding increased investment by business and government, investment in the development of strategic ICT capability is low, which may weaken the innovation base and the future competitiveness of the economy (page 15)*
- *Government support for business R&D is low by international standards, being less than half that of leading OECD countries. Australia – with direct plus indirect support at about 0.09% of GDP – provides less support than all but one of the comparison countries, whereas the United States (with support totalling almost 0.30% GDP) is the most generous (page 300)*
- *Over the past 30 years there has been a rapid growth of world trade in manufactured products. Australia has not been a strong participant in this expansion, unlike such countries as Canada, Sweden, Finland and the Netherlands. Australia has built neither large Australian-based firms , nor areas of strong specialisation, in trade and technology-intensive industries. In 1913, the value of Australian exports was about the same as that of Canada and the Netherlands and five times that of Finland. By 1988, Canadian and Dutch exports were about four times greater than Australian exports, and Finland's exports were only slightly less (page 30)*

Of importance is the flexibility with which the commercialising companies can interact with the research sector and, especially, its publicly funded infrastructure. In the pre-competitive phase, the technical and commercial risks are still very high for companies. Encouraging effective innovation, especially within the SME-dominated industry of Australia, cannot take place if access is at full-cost recovery compared with the more generous academic access regimes that have existed in, for example, MNRF and university-based facilities.

It is the case that the majority of current major research infrastructure has little or no relevance to what Australian industry requires in their shorter-horizon research needs.

Even when there might be relevance, unless the potential of the resource to make near-term bottom-line benefit to industry is made clear, industry will not be interested. Communicating benefits of infrastructure to industry is not something to be done by research scientists. The language must be that of the technologist and engineer in an economic context. Therefore, translating the benefit could well require specialist services.

Strategies in other countries

In looking for possible exemplars overseas, it is much more appropriate to look at the smaller states of northern Europe and Scotland where the underlying education, legal and social structures are very much closer to those of Australia and its States than is the case of America. These countries have been able to transform economies and build high-technology, high-growth clusters. The most obvious difference from Australia is the unashamed and clear use of language and understanding that it is "technology" and "engineering", rather than "science", which are the drivers of this commercialisation and innovation development. The flow-on consequences are a closely aligned research agenda between industry and public sector, public funding bodies better attuned to the strategic and medium-term needs of an emerging industry, an education system closely aligned with real needs and opportunities, and a public policy discussion and consequent agenda which demonstrate a competent understanding of what an effective national innovation system actually consists of.

Summary

The issues involved in enhancing in Australia a culture of technology-based innovation and of high-technology, high growth clusters exporting knowledge-intensive products and services is both historically-based and complex.

International examples do exist where the right language, right education, right public investment and right polices have enhanced the structure of the economy and developed sustainable wealth and jobs.

Great opportunities have been deliberately missed in Australia's past and potential opportunities are currently slipping by.

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PS I would be willing to expand on any item considered relevant to the working of the Committee.

BRIEF CV

Trevor Cole is the Peter Nicol Russell Professor of Electrical Engineering at The University of Sydney with a doctorate from the Cavendish Laboratory in Cambridge. He is also part-time Professorial Fellow at Macquarie University's Institute for Innovation. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and sits on the Federal Government's Industry Research and Development Board. For a number of years he was Executive Director of the Warren Centre for Advanced Engineering and Chairman of the Australian Microelectronics Network.

His major focus is the creation of wealth and jobs through the successful development and marketing of technology based goods and services.

During his career, amongst other things, he has spent a short time in a venture capital company, co-founded a speech technology company and he took a very significant role in initiating the Australian Technology Park. He chaired the R&D Board of Australia's Overseas Telecommunications Corporation and acted as CEO at the formation stage of the Australian Graduate School of Engineering Innovation. He played a major role in the National Innovation Summit in 2000. He has led study tours to northern Europe and to Canada/USA on innovation systems and technology commercialisation. He also created and delivered a series of courses in technology commercialisation and entrepreneurship.