Technology Strategy For a Troubled Economy at the Edge of the World

Ron Johnston, Don Scott-Kemmis, Terry Darling

'Far out in the uncharted backwaters of the unfashionable end of the Western Spiral arm of the Galaxy lies a small unregarded yellow sun. Orbiting this at a distance of roughly ninety-two million miles is an utterly insignificant little blue-green planet'
(Hitch Hiker's Guide to the Galaxy)

Identifying the Australian Problem

We begin with what is by now a familiar, if dismal, picture of Australia's declining terms of trade over the past twenty years (Fig. 1). The most widely accepted explanation is that the structure of our production and trade no longer provides the basis of a viable economy. Commodity-based production still generates the greater part of our export income. Yet, if we rely on that sector where ever-increasing volumes of exports are required to produce the same revenue, our economic decline will continue.

The logical answer, it has appeared, is to move into the rapidly growing sectors of world trade, like high technology manufacturing (particularly information technology) and services. Policies have been put in place to encourage industrial R&D, expand the availability of venture capital, capture the output of public sector research institutions and obtain a greater local effort from multinational firms and enhance exports.

These policies are meeting with some significant successes, but the world-class firms remain few and failures have been notable. The balance of trade in elaborately transformed manufactures remains disastrously in deficit. Perhaps the strongest lesson to emerge from the attempts of the last five years to establish an internationally competitive, export oriented, high technology manufacturing industry is just how hard it is.

It may be timely, therefore, to examine more carefully, not the objectives of transforming the Australian economy, but the means of doing it. What are the critical dynamics in transforming a primarily low value-added commodity-based economy into a high value-added, brain-based economy? And what are the biggest barriers? We propose to examine three major factors.

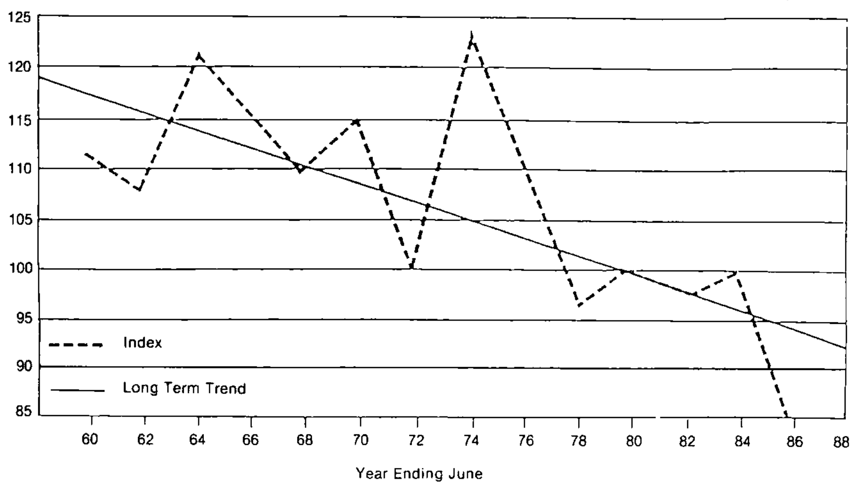
- **The Rules Have Changed**

We are now in the midst of what has been called a change in techno-economic paradigm — a fundamental change in technology and supporting industrial and economic structures. The 'structural crisis of adjustment' which ensues is frequently a painful and conflict-ridden process. We are now experiencing just such a process in Australia caused by a mismatch of economically and technologically generated requirements with the established institutional and social framework — an adjustment occurring in our industrial structure, in our labour markets, in the higher education system and in the CSIRO.

'A new techno-economic paradigm makes many of the previously acquired skills and externalities either redundant or a dead weight . . . Since the structural changes involved require specific facilitating conditions in the social and institutional spheres the process is prolonged and full of obstacles.[1]*'*

FIGURE 1

Australia's Terms of Trade Following the Declining Fortunes of Commodities (index 1980 = 100)



How have the rules changed?

First, technology is now the major determinant of patterns of world trade and investment — not land, not resources, not capital, (which follows technology), not labour (no matter how important skill is). New technology-based sectors are the most rapidly growing sectors; 40 per cent of world trade, by value, is predicted to be in information technology (in all its aspects) by the early 1990s.

Second, markets have become globalised, and firms, technology and

Edited version of a paper presented to the Meeting of Members of the Rural Research Councils at the National Press Club, Canberra, 14 April 1989

Professor Ron Johnson is the Director of The Centre for Technology and Social Change at the University of Wollongong.

the division of labour internationalised. Indeed, it has been argued that it is only the relationship between the production system and the innovation systems which justifies an emphasis on the national level at all; every other element disregards national boundaries.

Third, the barriers between traditionally distinct economic sectors i.e. the primary (agriculture and natural resources), secondary (manufacturing) and tertiary (services) are dissolving. Thus the primary sector uses and can produce goods for the manufacturing and service sectors. Almost all tangible goods are associated with services. Information technology is penetrating and transforming the primary sector. In sum, the traditional sectors are not only inextricably linked; they are in the process of becoming so inter-penetrated that they can no longer be regarded as distinct.

This suggests a particular 'crisis of adjustment' likely to emerge at some time in the near future as our present Ministerial structures and division of responsibility become subject to increasing tension as the traditional boundaries between industrial sectors dissolve.

Fourth, research — particularly the manner of its organisation — is being dramatically transformed. The assumptions of the scientist contributing to the international pool of knowledge, in which all can freely fish, is entirely inappropriate when knowledge is the key to international competitiveness. Research has become both too expensive and too important to be governed by a model of serendipity. Instead, it must now be managed, but in a way that is appropriate to supporting and enhancing the creativity essential to scientific production.

• The Problems of Scale

In terms of GDP, population and influence, Australia is a small country. Being a small country poses a number of serious problems[2], particularly with regard to technology-based manufacture.

Small countries have less money, in absolute terms, to spend on R&D than do big countries. They are therefore forced either to spread their resources thinly over all sectors and disciplines, or else to concentrate them by selecting priorities. The smaller the country the lower will be the number of fields or industries in which it can undertake R&D and the higher the number in which the minimum entry cost will be a barrier.

The lack of an extensive technological and industrial infrastructure also leads to a greater orientation towards the agenda set by the international scientific community rather than to developing a national capability to develop, apply and diffuse the results and techniques of science and technology. As one of us said a number of years ago about Australia's marginal science and technology structures:

> *'The self-reinforcing separation of supply and demand is reflected on the one hand by the emphasis on basic research and the loose connections between goals of research and economic and social needs. On the other hand, the production system, with its dominance by overseas companies and low commitment to local development, produces little demand which could influence or re-orient the research system.[3]'*

Don Scott-Kemmis is the Program Director at The Centre for Technology and Social Change.

Small national size creates other limitations because the ever-increasing complexity of modern industrial systems requires the integration of a range of basic or generic technologies. Hence, in all sectors (and not just the fashionable high technology areas) a much broader spectrum of R&D capability is required to effectively exploit technologies. So the cost of competing effectively is increased.

Smallness of size is not without its difficulties even in pursuit of the strategy favoured for small players — the 'niche' strategy. For the effective pursuit of such a strategy does not mean, as some assume, that intelligence requirements (in the sense of information) are reduced. To the contrary:

> *'To permit such a strategy, the small country would need to develop a high-level intelligence gathering capability in order to identify world trends in output, demand, market potential and scientific and technological developments, forecast the trajectory, analyse the opportunities and constraints of new development and then direct its limited R&D resources to projects selected for their potential to generate innovations able to fill identified market niches.[4]'*

This is obviously a very considerable demand, requiring not only significant resources, but extensive and wide-ranging institutional capabilities.

However, a number of small countries have long since developed dynamic open economies and industrial structures oriented to world markets. How have they overcome the disadvantage of small size?

Firstly, successful small countries have reacted more promptly to changing world conditions than large countries, and have been more flexible in their science and technology policies. Hence, smallness of size has been an advantage in times of rapid change because of the benefits of adaptability and flexibility.

Secondly, and more significantly, successful small countries have developed patterns of production and trade marked by a high degree of specialisation which generates a high level of both imports and exports.

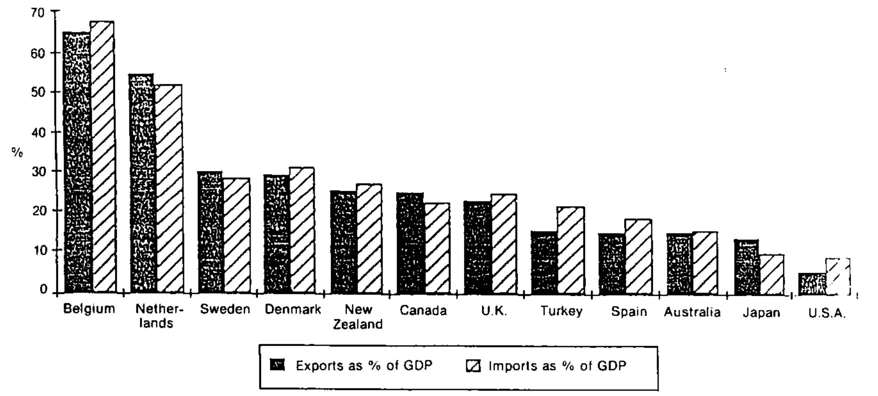
• Trading on Strengths

In general there is an inverse relationship between the size of an economy and its dependence on trade. The graph of imports and exports for a range of countries (Fig. 2) clearly shows the high proportion of both exports and imports, as a proportion of GDP, for small countries, and the correspondingly lower level for large countries. On average, small capitalist countries export 37 per cent of GDP, whereas large countries export only 20 per cent. A similar ratio holds for imports.

What is the explanation for this systematic difference? First, if small firms and nations do not have access to a large domestic market, they have to export to expand. As the managing director of Nokia-Mobira, the international Finnish electronics company, is reported as saying:

FIGURE 2

Imports and Exports of Goods as per cent of GDP



Source: OECD (1987a)

'When an inventor in Silicon Valley opens his garage door to show his latest idea, he has 50 per cent of the world market in front of him. When an inventor in Finland lifts his garage door (if he can), he faces 3 feet of snow.'[5]

Second, with the rapidly increasing costs of R&D, and the shortening life cycle of products, firms are faced with deciding either that they cannot afford R&D or that they have to have access to a sufficiently large market in order to be able to amortise their R&D investment.

In summary, economic survival requires international competitiveness, international competitiveness requires access to large markets and high volumes of trade, and access to large markets requires international competitiveness.

How does a small country like Australia compare with other successful small countries? Examination of Figure 2 shows that we have a pattern of trade, both imports and exports, measured as a proportion of GDP, much more like countries with huge domestic markets, like the US and Japan. We trade as if we were a big country. But because we are not, what that means is we do not trade very much at all, by international standards.

As one of us wrote recently in the Australian Financial Review on the subject of the balance of payments:

'The focus on how to reduce the level of imports — the cars and cognac — misses the core of the issues . . . Successful countries have high levels of import dependence in areas where local industry is not (and probably cannot be) competitive, and high levels of exports by internationally competitive segments of industry. There is no point proposing that Australian industry should be replacing imports across the board.'[6]

This approach is illustrated by two tales of industrial development — both from the Nordic region. The first is from Denmark:[7]

During the last decades of the nineteenth century, European agriculture found itself increasingly unable to withstand overseas (particularly British) competition on the corn market. As an alternative to protection, the emphasis of the primary sector in Denmark was shifted to the export of high-quality standardized products from animal husbandry such as butter, bacon and eggs.

The development of these new export products induced further changes and minor innovations were seen in many areas, including innovation in milk transport and dairy machinery, in the feeding of animals, in their genetic characteristics, in veterinary services and in measurement instruments for quality control. Out of this there has developed an internationally competitive manufacturing industry in dairy-related equipment. Table 1 shows the ten engineering products in which Danish companies dominate OECD exports.

The simple lesson is that the manufacturing industry grew out of the experience and needs of the primary sector.

Now to a much more recent example in Finland[8] — a country of only 5 million people in the frozen north with a hostile (at least until *perestroika*) neighbour. What are your images of Finnish products — saunas and salad bowls? Yet the careful reader of the Information Technology (IT) feature in the *Business Review Weekly* of 10 April 1989 will have noticed that a Finnish company is a world leader in mobile communication systems.

What is the connection? In 1960, when Finland began to industrialise, 100 per cent of its exports were of pulp, paper and finished wood products. By 1983, the proportion had declined to 38 per cent, but the value increased enormously to the equivalent of $US6 billion. This was not achieved just through design of exquisite wood products. Rather, the Finns built on their knowledge and experience in forestry and wood handling to develop forest harvesting machinery, automated wood processing and pulping equipment and paper-making machinery.

Finland now leads the world in electronics applicable to almost all aspects of the forest industry. One of the needs/opportunities was in effective remote mobile communications for scattered locations. This coherence of commitment culminated in the launch early in April 1989 of the Tele-X satellite, developed by Finland and other Scandinavian countries, designed to enhance mobile communications in the region.

Does Australia, with its long

Table 1

The ten engineering products with highest Danish export specialisation in 1975

Milking machinery and dairy equipment	15.2 (9.3)
Mineral crushing and glass-working machinery	5.2 (5.4)
Agricult. mach. for cultivating and harvesting	4.7 (2.7)
Food-processing machinery (excl. domestic)	4.3 (2.2)
Agricult. mach. and applic. not elsewhere stated	4.0 (1.2)
Domestic electrical equipment	3.1 (0.8)
Heating and cooling equipment	3.0 (4.2)
Batteries and accumulators	2.9 (1.9)
Elec. measurement and control instruments	2.6 (1.3)
Pumps and centrifuges	2.4 (3.3)

Source: Andersen and Lundvall, *op. cit.*

history of an internationally competitive cereals industry, lead the world in cereals harvesting equipment, new types of cereal-based products, special forms of transport over cereal-type terrains, IT systems relevant to this industry? Even more rhetorically, where do we stand in coal mining equipment, underground communications systems, electronically controlled transport, surveillance? The list of missed opportunities is limited only by the imagination.

What is the key to the Danish and Finnish experience? It is the pattern of specialisation, which in turn is dependent on strong and lasting user-producer contacts which support a process of learning by interaction between suppliers of materials, products, equipment, services and a sophisticated domestic market. As anyone with practical familiarity of the rural sector would know, innovation does not arise only from R&D laboratories. It also occurs right through the industry at all levels, largely as a consequence of a wide range of interactions.

We can go further and argue that laboratory R&D is most effective when it is firmly linked into the user-producer environment, both in identification of problems/opportunities and delivery of results. It may be far more important for small countries to ensure they have 'leading edge users' of technology, in contrast to the usual pursuit of leading edge producers, and leading edge science.

One further point to draw from the Finnish experience: research and training in universities and public sector institutes had a primary objective of technology transfer, to keep up with the progress of the technological frontier, and to translate it into forms in which it was readily available to industry. The technology transfer function is often used as a justification for public funding of research, but only rarely organised to specifically achieve this objective.

Four Lessons for Australia

1. The solution to our balance of payments deficit is not import controls. Rather, we need to expand both our exports and imports. This can be achieved by introducing a far greater degree of specialisation and concentration into our economy. As a small country we must devote much more effort to becoming a nation of traders. We need to develop a mental image of our country as a Singapore, or a Hong Kong, having to trade to survive. And we need therefore to focus much of our effort on improving the key elements of our infrastructure which are critical to expanded external trade, namely; transport, communications and language, and cultural education.

Terry Darling is Project Officer at the Centre for Technology and Social Change.

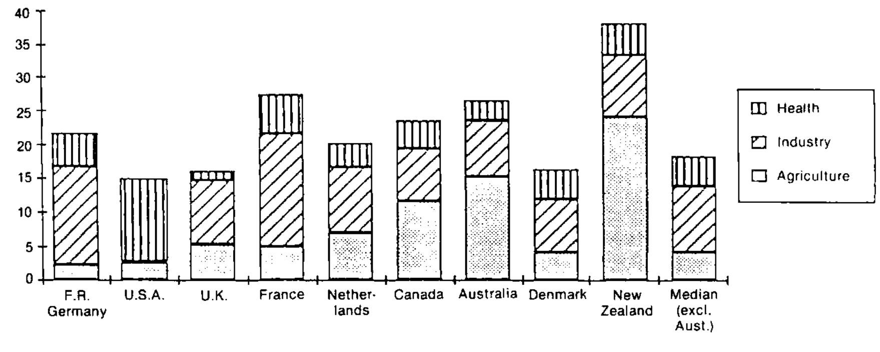
2. The primary sector has been, and continues to be, the backbone of Australian exports. It is the one sector in which Australia is substantially internationally competitive. One of the reasons for this has been the very substantial level of public funds which have flowed to this sector. Thus, Figure 3 shows that a far higher proportion of GDP has been committed to agricultural research compared with most countries. The second element has been the very strong user-producer relationships within the specific confines of that industry.

   The lesson of the past success is not simply, as sometimes claimed, that more public funds should be invested in supporting R&D. Rather it is that a combination of carefully invested and managed public funds, high quality researchers and strong producer-user relationships can provide the kind of advantage needed to establish major internationally competitive industries.

FIGURE 3

Government R&D Funding by OECD Socio-Economic Objectives

(Cents Expended per $100 of Gross Domestic Product)



3. Three strategies have been extensively promoted for Australia's economic recovery. These have been summarised as:
   - Concentrate on primary industries where we have a comparative advantage;
   - Manufacturing is the sign of a developed nation and must be central to economic growth;
   - High-tech will save the day.[9]

Under the conditions of the present structural crisis of adjustment none of these is appropriate on its own and conflict between proponents of each is pointless and destructive.

What is needed is a combination of all three, which links the development of a national microelectronic capability with applications in the primary sector, the generation of applications software for rural industries, and so on. We must achieve the critical mass in innovation which has marked almost all Australian notable technological successes.[10] A number of small starts have been made, but the imperial curse of division between sectors, between researchers and users, between government, industry and the labour force, all severely limit the making of linkages the Australian economy and our society so desperately need.

Radical mechanisms are needed. For example, a prime item for the agenda of the recently announced Co-ordinating Committee for Science and Technology, under the chairmanship of Professor Ralph Slayter, should be the establishment of mechanisms to explore the barriers to more effective linking of technological opportunities between the primary, manufacturing and service sectors, to identify areas of promising interaction, and promote their development and exploitation.

A great deal of innovation occurs in the primary and minerals industries in Australia which is never transferred to the marketplace. The view that the benefits should be realised through improved productivity is no longer adequate — the returns to the nation are insufficient. Mechanisms to encourage the transfer and exploitation of this technology need to be established. One example would be a series of rural innovation centres.

4. Research must be far more effectively managed. Judgement by peers, resource allocation according to proposal pressure, identification of problems through panels of users — each have their value but they are no longer sufficient. In a small country like Australia, our resources are so few and the critical problems so great, that research funding bodies need to see their task not just in terms of supporting research, but in transforming industry, and developing new clusters of international competitiveness.

Priorities need to be determined proactively. Furthermore, the range of decisions to be made can no longer be resolved by experience alone. They include:

- where to intervene in the production cycle — development of a new variety, increased pest resistance, lower fertiliser needs, lower cost harvesting, improved transport and storage, development of new applications, design, marketing;
- what are the important niches and how can they be identified?
- what are the avenues of new technological development being pursued overseas and where are the new markets?

A growing body of analytical techniques to assist in opportunity identification, priority setting and research evaluation need to be used. The making of decisions about research funding is now so important that a greater level of resources will have to be devoted to improving the way in which these decisions are made and in getting a greater proportion of them right.

References

1. Perez, C. 'New Technologies and Development' in C. Freeman and B. Lundvall (eds.) *Small Countries Facing the Technological Revolution*, Pinter Publishers, 1988.
2. Walsh, V. 'Technology and the Competitiveness of Small Countries: A Review' in *Freeman and Lundvall, op. cit.*
3. Johnston, R. 'The Critical Barriers to the More Effective Appreciation of Research Results' in A. Birch(ed.), *Science Research in Australia: Who Benefits?* ANU Press, 1983.
4. Green, K. 'Research Funding in Australia: A View from the North. Department of Science, Canberra, 1985.
5. Quoted in Lemola T. and Lovio R., 'Possibilities for a Small Country in High-Technology Production: The Electronics Industry in Finland' in *Freeman and Lundvall, op. cit.*
6. D. Scott-Kemmis, 'Imports Debate is Lopsided', *Australian Financial Review*, 6 March 1989.
7. Andersen E.S. and Lundvall B. in *Freeman and Lundvall, op. cit.*
8. Lemolo and Lovio, *op. cit.*
9. Teggart G., 'The Changing Face of Australian Manufacturing: Does It Need Reconstructive Surgery', Address to the Australian Industrial Research Group, February 1989.
10. McLean R.J., 'Linking Research and Innovation to Global Opportunities' Infl. C. Marsh, *Australia Can Compete: Towards a Flexible Adaptable Society*, Longman Cheshire, 1988.

Fact Versus Fiction on Climatic Change

Institute members in Queensland were recently presented with a national analysis on expected climatic changes. Suffering from a flood of popular press articles on the topic, those members who attended the August meeting of the Queensland Branch learned that the paucity of facts and the complexity of meteorological mechanisms make it difficult to predict quantitative changes.

The use of models enables directed research into the problem by agricultural researchers at the local level. Studies of the implications of a change in the summer/winter rainfall distribution will be effective if they are regionally directed and assume an increase in climatic variability. Plant responses to increased carbon dioxide levels and the effects of land degradation were considered in detail with the four speakers, Geoff Crane, Greg McKeon, David Doolen and Ken Couplan debunking some of the myths surrounding the topic of expected climatic change.