PRIME MINISTER'S SCIENCE, ENGINEERING AND INNOVATION COUNCIL

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AUSTRALIA'S INFORMATION & COMMUNICATIONS TECHNOLOGY (ICT) RESEARCH BASE

DRIVING THE "NEW ECONOMY"

This paper was prepared by an independent working group for PMSEIC. Its views are those of the group, not necessarily those of the Commonwealth Government.

Executive Summary

The primary conclusion of the Working Party is that while Australia has been a good user of Information and Communications Technology (ICT) it has not captured the major benefits of being a producer of ICT goods and services. This is demonstrated in Australia's export and patent performance. There are a number of structural and organisational factors which have influenced this situation. The Innovation Summit Implementation Group's report *Innovation: Unlocking the Future* and the Chief Scientist's report *The Chance to Change* have both identified a range of these issues which relate to technology intensive innovation and have made recommendations to address them.

The Working Party found that, in addition, Australia's failure to gain better outcomes from ICT research and development (R&D) relates primarily to the current small scale of effort in Australia's research, training and infrastructure (eg high performance computing and microelectronics).

In the short time available the Working Party has not been able to undertake detailed analysis of all the issues related to the development of a technologically based, export focussed ICT industry. However, it is absolutely clear that the rapid ICT developments are providing a stream of new opportunities which are creating new firms and new industries. The ultimate objective of Australia's investment in R&D is to realise these opportunities and to participate in the fast growing global ICT markets. Accepting that Australia will simply be an adopter misses the opportunity to take advantage in terms of jobs and wealth from the many current and future ICT opportunities.

In the Working Party's view Australia has failed to take advantage of the new technologies in part because of the weak R&D effort. Addressing this weak effort lays the foundations for building new skills, capabilities and industries. Past Government efforts to stimulate the development of new ICT intellectual property have been inadequate, and have led to a focus on using ICT rather than creating an environment for ICT innovation. In part this can be attributed to Government R&D investment not changing to reflect the increasing economic significance of ICT.

In contrast, Australia has consistently invested in the life sciences, which has resulted in our strong international patent performance, new firm formation and growth of exports in this field.

Other developed and developing countries have been more committed to ICT than Australia over the last two decades, a commitment which is reflected in their industry growth and export performance. Australia’s strong economic performance, on the other hand, is more attributable to the Government’s (laudable) focus on microeconomic reform rather than a strategic investment in ICT. As ICT is so fundamental to competitiveness it is essential that Australia act to strengthen its investment in ICT research, training and technology transfer infrastructure to ensure our weakness does not constrain the country’s economic growth potential.

Recommendations for ICT R&D

1. Increase the level and quality of public sector ICT research and development and enhance the scope for commercialisation of research outcomes.
Total Cost $555 million over 5 years

2. Significantly improve the capability of Australia's ICT research and development infrastructure.
Total Cost $161 million over 5 years

3. Increase the level and quality of private sector ICT research and development.
Total Cost $30 million over 5 years

OVERVIEW

The critical nature of Information & Communications Technologies

Information and Communications Technologies (ICT) are recognised world wide as a key driver of innovation and economic growth.

International effort

Other developed countries, from Europe, the United States and Japan to India, China, and the Asian Tigers, are concerned about the capacity to maintain or raise the wealth of their country. These countries view strength in traded ICT products and services as vital to their future economic health. Because competitive advantages in high technology industries are created, countries such as Israel, Singapore, Taiwan, Korea, Canada, Finland, Sweden, Ireland and Scotland have acted strongly to support the growth of ICT based industry. Each has shown that small countries can build their ICT industries through a concerted national effort, including the necessary underpinning educational activity.

Australia in contrast

In contrast, Australia does not have a concerted effort in this sector. Although there have been a number of past reports highlighting the critical importance of ICT, Australia has not invested adequately in ICT and, as a consequence, the economic benefits to Australia have not been realised.

ICT goods are the most compelling areas for investment because of strong demand and the new opportunities that constantly emerge. This demand has made ICT goods two of the three strongest growing internationally traded products, while resource based products, which traditionally dominate Australia's exports, have the lowest growth.

ICT is critical

ICT are critical technologies. They are pervasive, embedded and ubiquitous. They have a major impact on new product creation, new product features, process improvement and the creation of systems for services. The technologies underpin all other technology development, are essential to the competitiveness of all industries, facilitate service industries, upgrade efficiencies in commodity industries, and seed new industries. ICT are enabling, with strong spillover impacts across the entire economy. It is difficult to imagine any area of economic activity which has not been impacted by ICT.

Australia only a price taker

If Australia is only ever to be a purchaser of these technologies then it condemns itself to being a price taker for ICT goods and thus may not get first access to the latest technology. As a non-producer Australia will miss out on the benefits of the epic trade

growth in the sector. This is so despite the undoubted improvements being achieved through using ICT in diverse sectors such as banking, mining and manufacturing.

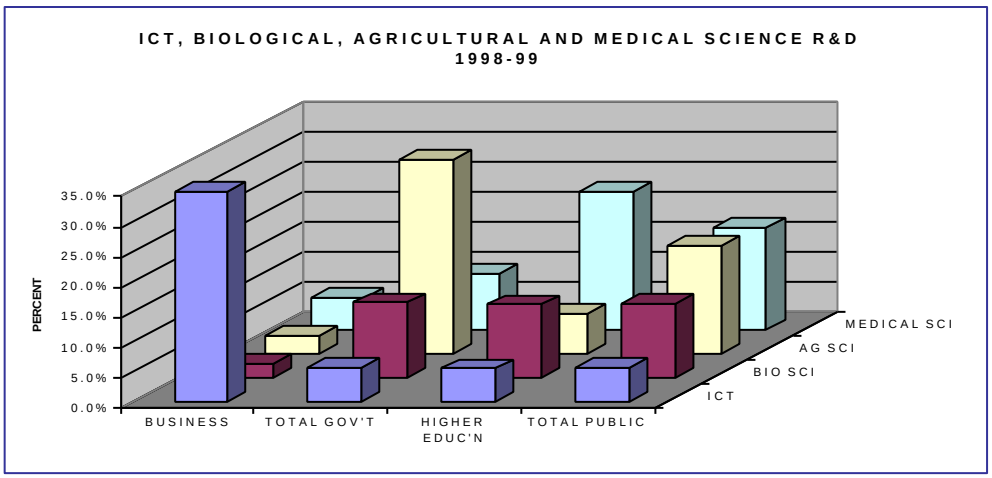
Australia – scale is the problem

Australia has but a small core of internationally competitive ICT manufacturing and software development firms. However the industry base is a significant part of Australia's manufacturing base and has over 1000 exporters, of which 41 are large companies (more than 200 employees). The manufacturing base and exports have contracted in recent years because multinational corporations (MNCs), which dominate, are changing their business paradigm and moving production offshore. Overall our industry is competitive but weakening. By comparison with most OECD countries Australia has failed to position itself to participate in the benefits from the many opportunities offered by ICT.

Australia's higher education system for ICT teaching and research is also deteriorating due to rising teaching loads and consequent reduction in research time. Large salary differentials between universities and industry are causing a loss of capability in research and education and therefore the capacity to educate and train the next generation of ICT specialists. This decline in teaching and research staff, combined with increasing numbers of undergraduate students, places further stress on the system.

Australia has not invested strongly in public sector ICT. For example, in terms of share of CSIRO's 1999-2000 appropriation funding, support for ICT was only 4.6% compared with 6.6% for wool and textiles (TCF). The bigger picture shows the massive Government support in 1998-99 for agricultural science (32% of Total General Government Research & Development (R&D) expenditure), biological science (12.3%) and medical & health science (9.1%) which together account for over 53% of Total General Government R&D expenditure compared with only 5% for ICT.

Chart 1: Australian Research and Development in Key Fields of Research 1998-99



Source: ***Australian Bureau of Statistics***

This contrasts with industry investment in R&D of 34.6% for ICT, compared with only 10.2% in life sciences, comprising 2.2% for biological science, 2.7% for agricultural science and 5.3% for medical & health science.

This focus is reflected in our poor international ICT intellectual property (IP) performance. In contrast, Australia is well positioned to take advantage of biotechnology as Australia's life science patenting is above the world average and growing.

Overall Australia's capability to maintain the R&D effort necessary to generate traded ICT goods has been contracting while in other developed countries it continues to expand as the basis of new wealth creation.

Australia's current industry structure works against the rapid generation of substantial exports in large part because of the dominance of MNCs which largely operate sales and service operations (although a number have established local research centres). However, ICT generates many new technology based opportunities for creation of new firms.

New firm formation is important

High technology based new firms have the best prospects of becoming strong, rapidly growing companies generating new high paying jobs and exports. Because of their high growth characteristics, new ICT firms are the primary recipients of venture capital investment. A strong focus on new ICT firm formation is the primary means of generating increased benefits from ICT R&D.

However, the low numbers of ICT firms on the Australian Stock Exchange (ASX) reflect past low domestic ICT IP formation. This situation can be reversed over time. To capture the benefits of ICT, Australia needs a strong research base (including research training), commercialisation infrastructure, venture capital industry, and strong support for small and medium enterprises (SMEs) going global.

There are many new frontiers in ICT R&D, but Australia has relatively strong research efforts in only a quarter of the more than 28 individual ICT research fields. Australian research is little cited internationally indicating what work we do is, on average, of poorer quality against world standards. Australia needs to strengthen and broaden its ICT research effort to be better placed to take advantage of emerging ICT opportunities.

Over the last two decades, a new paradigm for world investment has emerged. ICT has enabled MNCs to be more selective in the location of production and research facilities, based on factors such as market access, relative production costs and availability of scarce skills. While MNCs have been an important part of our economy, Australia cannot rely solely on MNCs to generate future growth. Australia needs to focus on creating new wealth through domestic capital formation around Australian created intellectual property.

Strong R&D critical

A strong domestic R&D base generates skills which in turn attract increased local R&D activity by MNCs. MNC investment in R&D builds the domestic pool of leading edge researchers, increasing the scope for new IP to be created in Australia.

The larger pool of researchers also provides local industry with access to scarce skills to underpin its ICT innovation efforts.

Leading edge research requires researchers of the highest calibre to lead research teams, in turn attracting other high calibre researchers and postgraduate students. Research is often cross disciplinary and needs combinations of research groups working together to achieve significant advancements leading to new intellectual property.

Strong research centres bring together strong research groups which increase Australia's research depth, upgrade training and deliver wealth in the knowledge economy.

Strong infrastructure to support research and development

Having the right infrastructure to underpin the ICT Engine and support research and commercialisation is also important. It should include:

- High Performance Computing facilities to support optimisation, modelling and simulation by researchers resulting in products with shorter times to market.
- Test networks and testbeds to develop, prototype and evaluate communications products and services before use on commercial networks.
- Access to microelectronics technology to support training, research and industry product innovation.

The Working Party has been dismayed at the views put to it by a number of universities and Australian Information Economy Advisory Council (AIEAC) about the current fragile state of the ICT training infrastructure. The statistics on student/staff ratios suggest that the concerns are well founded. Combined with the significant shortages emerging in ICT skills in Australia (and most other developed countries) competition for high calibre skills is already intensifying (eg, Canada's initiative to create 2,000 new professorships). If Australia does not respond, as other countries are doing, to revitalise ICT training, increase training capacity and seek to retain its most highly trained people, then we will not be able to maintain our current levels of performance. The most critical shortages are in high-end ICT skills. This is a very critical strategic issue facing the Australian economy and its capacity to keep pace with opportunities provided by ICT.

Australia is characterised by a strong domestic market for ICT offset by historically low levels of government funding for ICT R&D in public sector research organisations and universities, a weakening research situation in universities, with only few high points, and relatively low levels of business ICT R&D. Given the excellent potential for generation of commercially valuable IP and strong international competition for a share of the new

wealth, Australia needs to act decisively and on a competitive scale to position itself to exploit the new technological opportunities, broaden our industry, services and export base and generate new higher paying jobs. A secondary outcome will be that Australia will be appropriately recognised internationally as a technologically sophisticated nation and will attract new investment.

Benefits of R&D investment

A substantial and strategic investment in Australia's ICT R&D capabilities will:

- Attack Australia's weakness in capability in new and rapidly changing information and communications technologies.
- Achieve greater breadth and depth in ICT research and development.
- Attract foreign investment into leading edge Australian research.
- Demonstrate to other countries Australia's commitment to developing strength in fast growing, high technology, and tradeable products.
- Attract world renowned researchers and build a greater pool of scarce high calibre researchers (intellectual assets).
- Create new Australian companies.
- Impact positively on our trade deficit over time.

Recommendations for ICT R&D

A coherent and coordinated program of on-going Government initiatives will be required to enable Australia to take maximum advantage of the opportunities presented by the global ICT explosion. These initiatives will need to address the three key elements of the ICT Engine:

- The public sector.
- The ICT R&D infrastructure.
- The private sector.

Recommendation 1

Increase the level and quality of public sector ICT research and development and enhance the scope for commercialisation of research outcomes through:

- ***The establishment of two major ICT Research Centres of Excellence.***
- ***The creation of 20 ICT Research Chairs.***
- ***The creation of 35 ICT Research Fellowships.***
- ***The introduction of 5 ICT Demonstrator Programs.***

Total Cost: $555 million over 5 years

Recommendation 2

Improve the capability of Australia's ICT research and development infrastructure through significant and sustained investment in:

- ***High performance computing systems.***
- ***Advanced optical communication networks.***
- ***Digital Libraries.***
- ***3 Microelectronic Technology Centres and national support centre.***
- ***Increased participation in national and international standardisation.***

Total Cost: $161 million over 5 years

Recommendation 3

Increase the level and quality of private sector ICT research and development through:

- ***Using Government negotiating power to encourage MNC's to undertake more R&D in Australia.***
- ***Strengthening the R&D requirements in telecommunication carrier Industry Development Plans.***
- ***Development and implementation of a program to facilitate Australian ICT SME's to achieve a significant global presence.***

Total Cost: **$30 million over 5 years**

The costings are based on implementation of the recommendations over periods of between two and five years. The recommendations would then require on-going support.

In addition to these specific recommendations there are a number of initiatives that have been recommended in either or both the Innovation Summit Implementation Group's report *Innovation: Unlocking the Future* and the Chief Scientist's report on Australia's Science Capability *The Chance to Change* which the Working Party endorses. Finally, there are a number of issues that have been raised by stakeholders as a result of the Working Party's consultative efforts which, while not reflected in specific recommendations, are considered sufficiently important to flag as issues for serious consideration by Government.

In particular, the Working Party endorses ISIG and ASCR recommendations relating to

- SME cash out of the R&D tax concession.
- Expansion of the BITS and COMET programs.
- Establishment of Innovation Centres (including an ICT-specific Centre).
- Providing an additional 2,000 student places from 2002.

The Working Party also endorses the need for action in response to stakeholder comments to:

- Streamline immigration procedures to access overseas skills pools and encourage foreign students with high level ICT qualifications to remain in Australia and, in particular, to offer permanent residence to individuals with very recent PhDs.
- Improve on priority setting by government funding agencies including the Australian Research Council; ICT is an important but weak area; the Council needs relevant policies to remedy the weakness.
- Improve the university teaching system to cater for greater intakes of ICT undergraduates without adversely affecting ICT research.
- Make computer sciences postgraduate funding consistent with engineering and science postgraduate students.
- Ensure DETYA's research funding formula includes recognition as external income equity or income from the sale of equity in spin-off companies.

COSTINGS SUMMARY

PROGRAM ELEMENT	2001-02 ($m)	2002-03 ($m)	2003-04 ($m)	2004-05 ($m)	2005-06 ($m)	5 year Total ($m)
Centres of Excellence	20	60	90	80	100	**350**
Research Chairs	10	20	20	20	20	**90**
Research fellowships	2.5	5	6	8.75	8.75	**31**
Demonstrator Program	8	16	20	20	20	**84**
Integrated Infrastructure	20	20	20	20	20	**100**
Microelectronic Tech Centre	5	9	13	12	12	**51**
Standardisation	2	2	2	2	2	**10**
SME Going Global	6.5	5.5	6	6	6	**30**
TOTAL	**74**	**137.5**	**177**	**168.75**	**188.75**	**746**

PREAMBLE

Information and Communications Technology (ICT) is almost universally regarded as a major driver of economic growth. Success in developing and commercialising new ICT technologies, as opposed to simply consuming them, is directly related to a nation's commitment to research and development.

The 1998 report entitled *Information Technology: Sink or Swim* prepared by the Australian Academy of Technological Sciences and Engineering (AATSE), raised a number of issues in relation to the lack of underlying strengths of IT&C research in Australia. The Report emphasised the necessity for increased government support to boost levels of ICT related R&D in Australia.

In July 2000, a Working Party of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) was convened to consider the matter of Australia's investment in ICT research and development (R&D).

Terms of Reference

a) Identify how Australia can maximise the benefits it derives from current and new information technology and communications research and development.

b) Identify any significant impediments to realising the benefits flowing from current or new research and development, and recommend possible steps that could be taken to remove or minimise them.

In addition, the Working Group studied the recommendations of the Chief Scientist's report *The Chance to Change* and the Innovation Summit Implementation Group's report *Innovation: Unlocking the Future* as initiatives on which to construct this report.

Working Party Membership

Chairman:

Professor Brian Anderson AO Pres AA FRS FTSE	Director, ANU Research School of Information Sciences and Engineering; President, Australian Academy of Science; and, Director Cochlear Ltd
Mr Norman McCann FAIM FAICD	Managing Director, Hewlett Packard, Australasia
Dr Roger Kermode	Principal Research Engineer, Manager, Motorola Australia Research Centre
Professor John O'Callaghan FTSE	Executive Director, Australian Partnership for Advanced Computing
Ms Johanna Plante	CEO, Australian Communications Industry Forum Limited
Mr Neil Bryans	First Assistant Secretary, Science Policy, DSTO
Dr Leith Campbell	General Manager, New Wave Research, Telstra

Secretariat Support

Mr Keith Besgrove:	Chief General Manager; Information and Communications Industries Division; Department of Communications, Information Technology and the Arts
Mr Greg Gurr:	Department of Communications, Information Technology and the Arts
Mr Drew Andison:	Department of Communications, Information Technology and the Arts
Ms Katherine Schmutter:	Department of Industry, Science and Resources

Consultation

In preparing this Report the Working Party met formally on four occasions and also engaged in a series of meetings with key stakeholders from industry and public sector research organisations as well as major ICT users. In addition a number of Round Table discussions were held to ensure that input was obtained from as broad a cross section of the private and public sectors as possible. The Working Party also sought and received written submissions from a wide range of interested parties. Details of the Working Party's consultative process may be found in Appendix 1.

ICT industry definition

The boundaries of what constitutes the information and communications industries are not clear cut because there is a convergence in the use of information and communications technologies in an increasing range of products and services. Some analysts include the content industries delivered by ICT as part of the industry. ICT is increasingly important to supporting growth in industries other than those which produce core ICT goods and services. In many of these industries ICT is incorporated into the products and services with some minor adaptation. However, the core ICT industries, in particular manufacturing, are the primary sources of new technologies.

The major segments of the ICT industry[1] are:

Hardware
- Network Equipment
- Terminal and Peripheral Equipment
- Computer Equipment
- Digital Television Equipment
- Electronics Manufacturing
- Semiconductors

Software
- Network and Operating Systems
- Application Tools
- Horizontal Applications
- Vertical Applications

Services
- Telecommunication Carriage Services
- Internet and Online Services
- Professional Services

[1] Report prepared by STM Consulting Pty Ltd for the Information Industries & Online Taskforce, Department of Industry Science & Tourism (1998)

CONTENTS

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DRIVING THE "NEW ECONOMY"

Information technology will be one of the key factors driving progress in the 21st Century … it will provide a vehicle for growth.

Vigorous information technology research and development is essential for achieving America's 21st century aspirations. The technical advances that led to today's information tools, such as electronic computers and the Internet, began with Federal Government support of research in partnership with industry and universities. These innovations depend on patient investment in fundamental and applied research.

Government-sponsored university research programs have supported graduate education for many of the leaders and innovators in the field. As we approach the 21st century, the opportunities for innovation in information technology are larger than they have ever been – and more important. We have a national interest in ensuring a continued flow of good new ideas and trained professionals in information technology.

President's Information Technology Advisory Committee,
Report to the President 1999.

ICT IS THE FOUNDATION OF ECONOMIC GROWTH IN ADVANCED ECONOMIES

1 PRODUCTION OF ICT GOODS & SERVICES IS STRATEGICALLY IMPORTANT

ICT is strategic

- *ICT is critical to industry performance and innovation*

  In 1995 the RAND Corporation[2] compiled a list of technologies that are regarded by US industry as critical to future growth and competitiveness:
  - Computer software
  - Micro-electronic and telecommunications technologies
  - Advanced manufacturing technologies
  - Materials
  - Sensor and imaging technologies.

  They are **all** ICT related technologies.

- *The ICT industry is a major creator of new wealth* ***outperforming other industries***.

  The US Government[3] estimated that, while IT industries accounted for only around 8% of the economy's total output in 2000, they contributed nearly **one third** of real US economic growth between 1995 and 1999. The US Federal Reserve Board concluded that ICT contributed two-thirds of the increase in US productivity growth between the first and second halves of the 1990s. The boost was substantially from **ICT production** as well as use of ICT. Because of the ongoing development of the Internet and e-commerce, ICT will contribute significantly to productivity and growth for some time to come.

  The US Department of Commerce noted that over the past decade, but especially since the mid-1990s, the ICT industries have been a powerful factor in the US economy's rapid and sustained growth, a significant restraint on inflation, and a focal point for prolific technological innovation.

  > ***'What differentiates this period from other periods in our history is the extraordinary role played by information and communication technologies.***
  > ***Most of the gains in the level and the growth rate of productivity in the United States since 1995 appear to have been structural, largely driven by irreversible advances in technology and its application.***
  > ***Our unemployment rate has fallen notably as technology has blossomed.'***
  >
  > ***Alan Greenspan, Chairman US Federal Reserve Board***

  In Finland, the electronic equipment industry (which includes the mobile telephone producer, Nokia) contributed three-quarters of one percent to annual GDP growth between 1995 and 1999, rising to 1.2 percent in 1999. In the Netherlands, the ICT-producing sector accounted for about 17% of GDP growth over the 1996-98 period, **four times its share** of GDP.[4]

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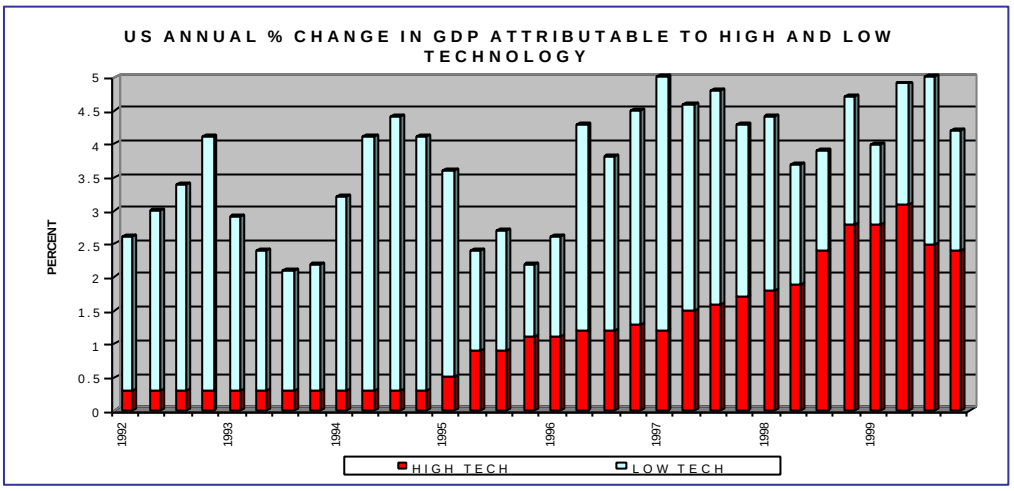
[2] : Rand Critical Technologies *Institute New Forces at Work: Industry Views Critical Technologies 1995*

[3] US Department of Commerce *Digital Economy 2000*

[4] OECD (2000), *A New Economy?* p52

Chart 2 shows that in the US the year on year growth in GDP attributable to high technology compared to low technology GDP has, since 1994, become increasingly significant.

Chart 2: Annual Growth in Low and High Technology Contributions to GDP

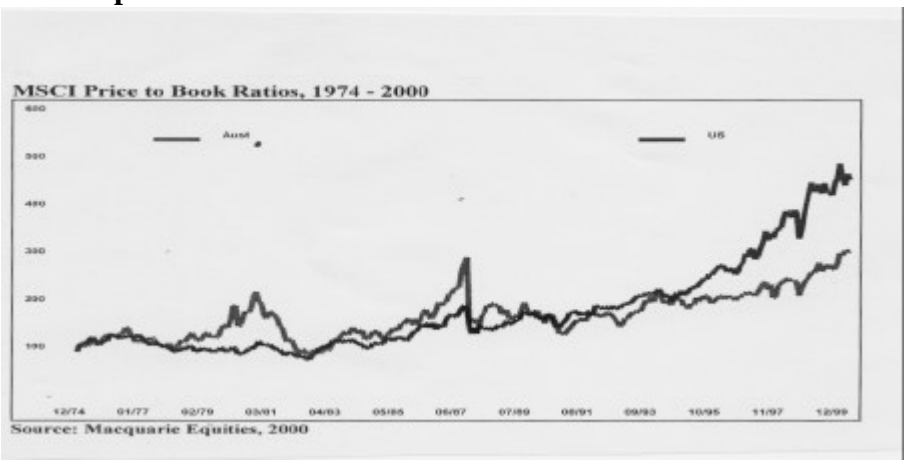


Source: Milken Institute 2000[5]

Greater importance of Intangible Assets

The commercial rationale for innovation is to create intangible assets, in particular intellectual property, unique skill sets, and patentable business models. The gap between the Australian and the US stock markets price to book ratios is to a significant extent (after discounting the emotional exuberance) a reflection of the creation of new wealth based on intangible assets.

Chart 3: Comparison of Australia & US Price to Book Values



Source: Macquarie Equities

[5] Milken Institute Policy Brief No 17 *Blueprint for a High-Tech Cluster* August 2000

The technology share of America's stockmarket capitalisation has expanded from 10 per cent in the early 1990s to about 30% today. By comparison the IT sector represents only 5.1% of the stockmarket capitalisation in Germany, 9.4% in France, 4.9% in Britain and 15% in Japan. The countries which have ICT sectors that compare with the market capitalisation of the US are Canada (29%), Taiwan (21.9%), Sweden (38.2%) and Finland (more than 50%). The telecommunications sector accounts for another 8.9% in the US compared with 16.5% for continental Europe, 16.1% for Japan, 18% for the United Kingdom and 15.1% for Asia less Japan.

In Australia only about 2% of the market capitalisation relates to IT and 14% to telecommunications.

- *The ICT revolution has only begun and offers a wide range of opportunities for innovation.*

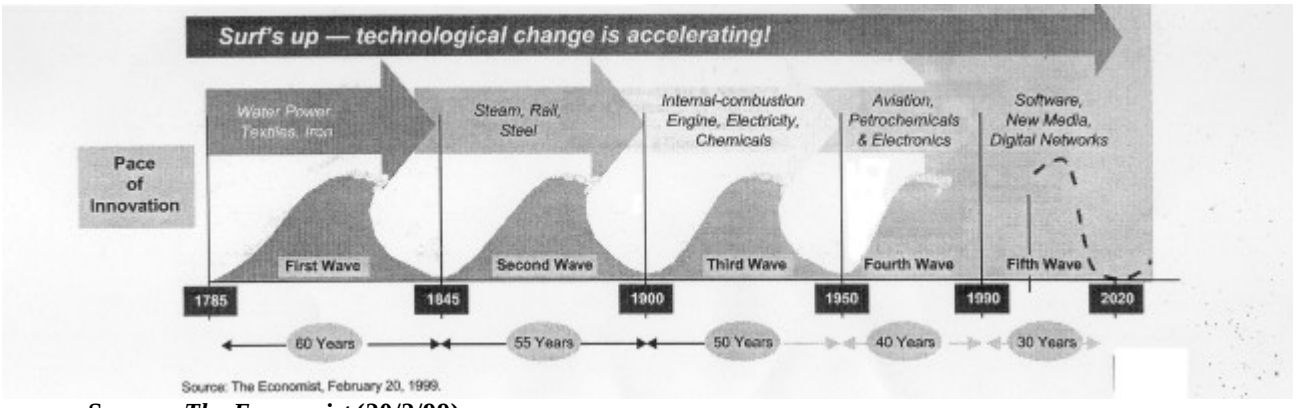
  ICT is changing the world (see Chart 4). Developments in communications, information processing, remote sensing, microelectronics, software development and artificial intelligence, have lifted economic productivity and enabled the creation of new intelligent devices and services. Most recently, the creation of the Internet has revolutionised many aspects of business (for example e-commerce and the seamless extension of companies' market reach across national boundaries), government and the home. The full implications of the emergence of the Internet have yet to be fathomed. ICT is driving research for new applications and infrastructure. It underpins company restructuring and industry modernisation through its impact on key competitiveness factors.

  A high powered integrated mobile phone/computer is commercially available. The video, wireless wristwatch communications device is very close to commercial release.

- *ICT is a disruptive technology.*

  ICT creates a major change in the basis for the creation of new wealth which will impact the world economy for decades to come. Perhaps most significantly, ICT has been responsible for the demise of the Fordist mass production paradigm which emerged in the 1930s.

Chart 4: Technology Waves



Source: *The Economist* (20/2/99)

- *The electronics industry currently ranks amongst the world's three largest industries.*

  ICT is one of the fastest growing global industries with worldwide sales projections in 2000 of $1,752,000 million.[6]

- *Internet related demand is a major driver of innovation and productivity improvement*

  "The total value of (worldwide) Internet purchases in 1999 rose to US$130 billion, a figure projected to reach US$2.5 trillion by 2004. Companies worldwide invested US$142 billion to create a web presence … and they spent an additional US$140 billion in business infrastructure related to electronic commerce."[7]

  Goldman Sachs has projected that increased IT investment and cost savings from business-to-business e-commerce will contribute somewhere between 0.55 and 0.8% to Australian labour productivity in the next ten years.

ICT Is Strategic To The Australian Economy

Australia is a leading user of ICT technology (see Chart 5):

- *ICT Businesses*

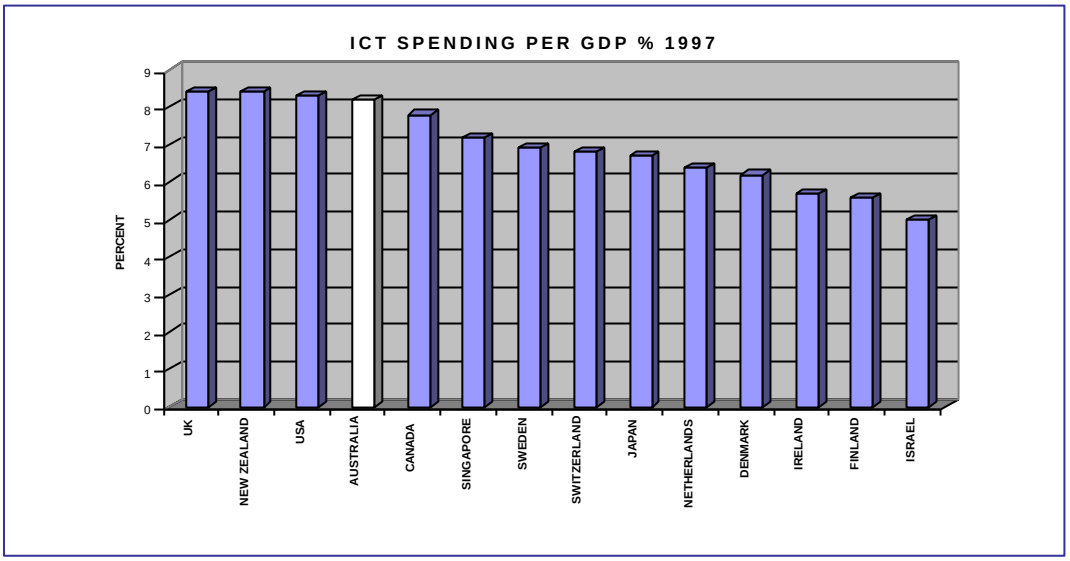
  At the end of June 1999, ABS identified 18,469 IT&T specialist businesses, an increase of 36% since the last survey in 1995-96. The majority, 14,546 (79%), were in the computer consultancy services industry, 1,398 (8%) in the computer wholesaling industry, 931 (5%) in the telecommunication services industry, 268 in manufacturing, 392 in computer maintenance, 261 in data processing and around 112 in information storage and retrieval. There were another 1,819 business involved in ICT activities, but this was not their primary business. The majority (1,635) were in wholesaling and the rest (184) in manufacturing.[8]

  'The Australian dollar has slumped in recent months because of perceptions that Australia is an old-economy country. The stock market has been lagging and unable to support the currency because of its limited exposure to the information technology sector. Software has a market weight of 1.2% and the internet sector is at 0.2%.
  If Australia waits, it will pay a cost in lost opportunity.'
  David Hale, Global Economist Zurich Financial Services Group

  There has been rapid business growth in Computer Consultancies while other segments of the ICT industry have contracted. This is reflected in the employment numbers below.

[6] Reed Electronics Research.
[7] World Information Technology and Services Alliance (WITSA) *Digital Planet 2000: The Global Information Economy*, p3, 2000
[8] A weakness in ABS data is the inability to separately identify Software Consultants and Software Producers

Chart 5: GDP Adjusted ICT Expenditure – International Comparisons



Source: OECD & World Bank

- *Business Use of ICT*

  Almost all (99 per cent) of businesses employing 100 or more people had computers compared to 46 per cent of businesses employing 1-19 people. Approximately 49 per cent of Australian non-agricultural businesses have computers.[9]

- *Domestic Use of ICT*

  In August 1999 3.4 million Australian homes (48%) had a PC – up by 2% on 1998. Nearly 23% of households had Internet access - compared with 18% in August 1998.

- *ICT Employment*

  At the end of June 1999, there were 195,580 persons working in IT&T businesses, a 4% decrease since 1995-96. A further 400,000 ICT specialists are estimated to be employed in other industries. This 4% overall decrease in employment in IT&T specialist businesses consisted of a 42% decrease across the manufacturing industries, an 11% decrease across the wholesale industries, an 18% decrease in the telecommunications industry with an offsetting 37% increase in the computer services industries. The growth in computer services is largely attributable to outsourcing and the creation of small consultancies by contractors.

Israel has about 300 software houses employing nearly 20,000 people with total revenue of over US$1.5 billion. Many receive US venture capital funding and most are engaged in developing sophisticated software packages for export. Companies such as IBM, Microsoft, Motorola, Intel and HP have established major design, research or software development centres in Israel.

[9] *Business Use of Information Technology* published in May 1997 by the Australian Bureau of Statistics

- *ICT Exports*

  Although thought to be small, Australia's ICT exports are not insignificant. ICT exports accounted for 11% of all industrial goods exports, including re-exports, in 1998-99 and IBISWORLD ranked ICT hardware as the top manufacturing exporter in Australia in 1998-99, outranking motor vehicles and pharmaceuticals.

ICT is Enabling

> ***Australia is suffering because it didn't follow the US example of innovation in the 90's.***
> ***Investment in research and development and entrepreneurship is the single biggest factor in the US economy.***
> ***Australia has not put the money into R&D.***
> ***James Wolfensohn, President of the World Bank***

Microprocessors represent one of the most fundamental electronic technologies. They are tiny devices which contain circuits and software to process inputs to create appropriate outputs, and in a sense are like a primitive computer on a single chip. However they are so powerful that they have transformed innumerable devices now in common use – for example, mobile telephones, retail security systems, automotive electronics, and office equipment. Microprocessors are also a base technology for many of the emerging industries – photonics, wireless technologies, biotechnology, and nanotechnology

ICT is increasingly Pervasive and Embedded in Manufactured Products

Computer makers take about 50% of all microprocessors produced. The telecommunications industry has become a major user as communications, computing and media converge into voice/data/video networks. Advances in medical and scientific instrumentation have seen these sectors also emerge as strong users. Consumer products and even motor vehicles have large numbers of microprocessors to control everything from power steering to antilock brakes and airbag deployment.

Features of World ICT Growth Identified by OECD

- ***Growth mainly driven by growth in telecommunications equipment and services. Hardware is the largest segment, but data communications play an increasing role.***
- ***OECD countries account for more than 80% of world ICT production and expected to continue to do so.***
- ***The United States continues to drive growth, being 36% of the world market.***
- ***Of the overall growth in patents granted by the US Patent and Trademark Office over 1992-99, ICT accounted for 31% and rose by almost 20% annually.***
- ***Technology flows play an increasing role in the balance of payments of OECD countries, and a growing share of exports originates from medium- to high-technology industries.***
- ***High-technology industries have experienced the greatest increase in international trade during the 1990s, much of which is intra-industry trade and reflects the splitting of production and innovation processes across the globe to take advantage of local knowledge and comparative advantages.***
- ***R&D intensive industries have higher wages, a greater capacity to create jobs and higher rates of profit.***

Conclusion

The rapid pace of innovation in ICT and its critical importance to innovation across the economy dictates a need to consistently invest in the ICT research and training infrastructure. Many countries, for example the United States, Singapore, Ireland and Scotland have recognised this and implemented policies to appropriately position their economies. (Appendix 5)

Countries will need a sufficiently developed scientific infrastructure if they want to benefit from the global stock of knowledge.[10]

[10] OECD (2000), *A New Economy?*

2 BUILDING HIGH TECHNOLOGY INDUSTRIES

Innovator countries are those that are continuously successful at discovering, developing, and commercialising novel products, services, and processes. As a result of sustained commitments to expanding innovative capacity, the historically small set of highly innovative advanced economies is expanding. Over the past several decades, a growing number of nations …. including Germany, Japan and some Scandinavian countries, have been developing the capacity to introduce state-of-the-art products and services, raising the standard that US companies must meet. A handful of newly industrialised nations are also beginning to make the transition from imitator to innovator, among them Singapore, South Korea, Taiwan and Israel. …. many of these countries are continuing to invest heavily in their innovation infrastructure and the development of clusters that can compete at the international frontier of technology. [11]

Developed economies are primarily concerned about their capacity to raise the wealth of their country. A commonly held view of countries from the United States and Japan to India, China, the Asian Tigers and many European countries, which is reinforced by economic research, is that strength in traded high technology products and services is important to their future economic health.

Singapore Government Policy

Info-communications have been identified as a key driver of economic growth in Singapore's knowledge-based economy. The Information and Communications Technology 21 (ICT21) study formulated strategies to make Singapore an e-business hub in the Asia-Pacific. These strategies build upon current approaches to attracting MNCs business HQs and international procurement offices in Singapore. The Government will examine how the Internet and Singapore's leading edge broadband infrastructure can be exploited to achieve the e-business hub.

Competitive advantages in high technology industries are created. As Israel, Singapore, Taiwan, Korea, Canada, Finland, Sweden, Ireland and Scotland have all shown, small countries can build their ICT industries through a concerted effort. The strategies adopted by these countries have been built on combinations of three elements:

1. Attracting MNCs to establish manufacturing plants
2. Building the national skills base
3. Strengthening the R&D base (including training capability) in key areas.

Specific policy initiatives in these countries are tailored to domestic situations. Countries such as Canada, Scotland, Ireland, Singapore and Taiwan have used a variety of incentives to attract MNC investments. For example Scotland undertook a cluster analysis to identify key weaknesses in training, skills, and transport systems to guide investment in a microprocessor design centre and in upgrading training and air transport facilities.

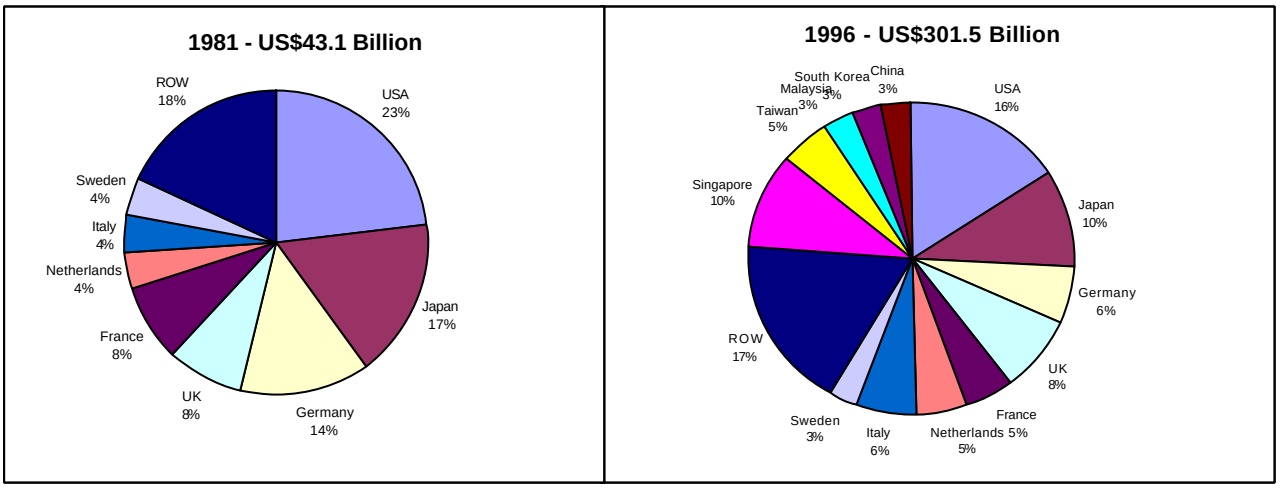
Australia should continue to focus on education and information technology.
The more intellectual capital you have here, the better the bet. Better educational system, better software development, more incubator work, more ideas.
Jack Welch, Chairman, General Electric

Chart 6 below shows the growth in the world ICT market from 1981 to 1996. What is remarkable is that,

[11] *Innovation Index*, Council on Competitiveness, p14, 2000

while the world market has grown seven times, the number of countries with a significant share of the market has grown from 8 to 13. There are also several significant countries such as Ireland and Finland not shown. The emergence of new players such as Singapore, Taiwan, Malaysia and South Korea, as well as the continued strength of countries such as the US, Japan, Germany and the UK reinforces the notion that globally ICT is of strategic importance.

Chart 6: Growth in Global ICT Market 1981 to 1996



Source: OECD *Measuring the IT Industry*

Australia's Past Policies

In contrast, Australia does not appear to have had a conscious focus on the establishment of a competitive ICT industry. Over the last twenty years Australia has moved from tariff and bounty based policies to support the ICT industry to a policy based on purchasing leverage and carrier licence conditions (see Appendix 2) which have clearly failed to stimulate the growth of a strong export focussed ICT industry base. Very little concerted action of any significant scale has ever been taken to position Australia to capture the benefits of the ICT revolution.

Ireland has, through its favourable economic climate, skilled and relatively low cost workforce and government initiatives aimed at establishing a nation-wide software oriented infrastructure, become the second largest packaged software exporting country in the world. Seven of the top 10 independent software companies have established facilities in Ireland with foreign owned firms accounting for nearly 84% of revenue and 88% of exports in 1998.

Australia's initiatives to provide key infrastructure to underpin and stimulate the growth of the ICT industry have been relatively small and piecemeal. The small Building IT Strengths incubators and networking and the IT Testing and Conformance program have been the first ICT specific initiatives.

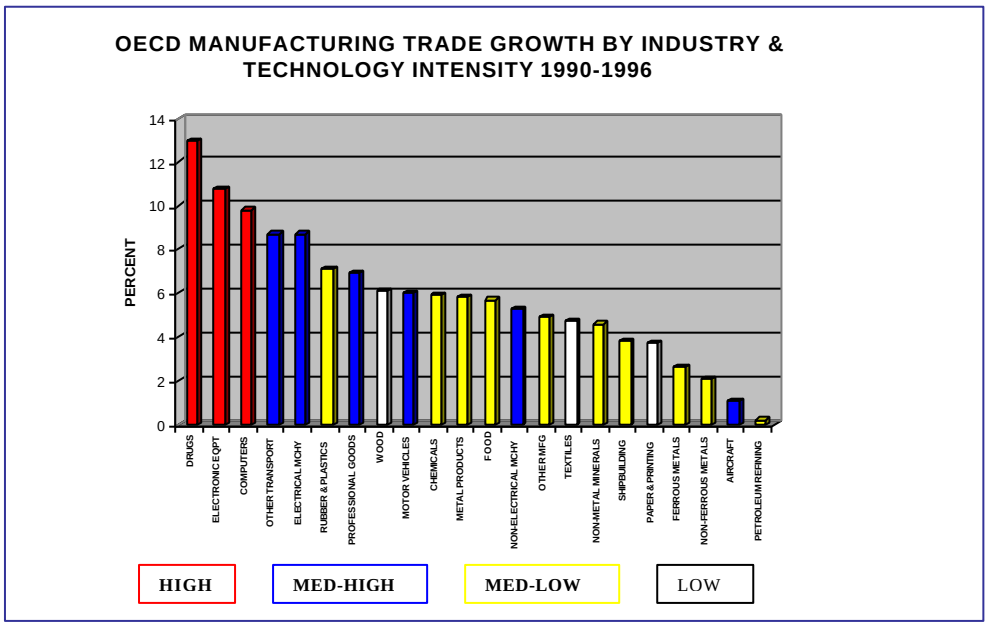
The Partnerships for Development and the Carrier Industry Development Plan programs have been valuable but have not provided Australia with a sustainable ICT export base, nor do they really address Australia's fundamental weakness in ICT research. As such, while the PfD program, for example, has encouraged MNCs to invest in Australia, overall it has not been sufficient to generate a strong, export oriented industry base growing at rates near to the world market.

3 ICT PRODUCTS DOMINATE TRADE AND TRADE GROWTH

High technology products, primarily ICT products, are the strongest growing internationally traded products. Resource based products, which traditionally dominate Australia's exports, have the lowest international rates of growth.

World exports in high technology products grew by 15% pa between 1985 and 1995, compared to less than 10% for all other goods. The growth rates between 1990-96 are shown in Chart 7. The knowledge intensity of world manufactured exports remained largely unchanged between 1970 and 1977, however since then it has increased steadily and persistently.[12]

Chart 7: Growth in Manufacturing Trade



Source: OECD

High technology exports comprise only a relatively small proportion of Australia's total exports, only 7.8% of total exports in 1999-00. The data reveals that Australia is still heavily reliant on raw material exports:

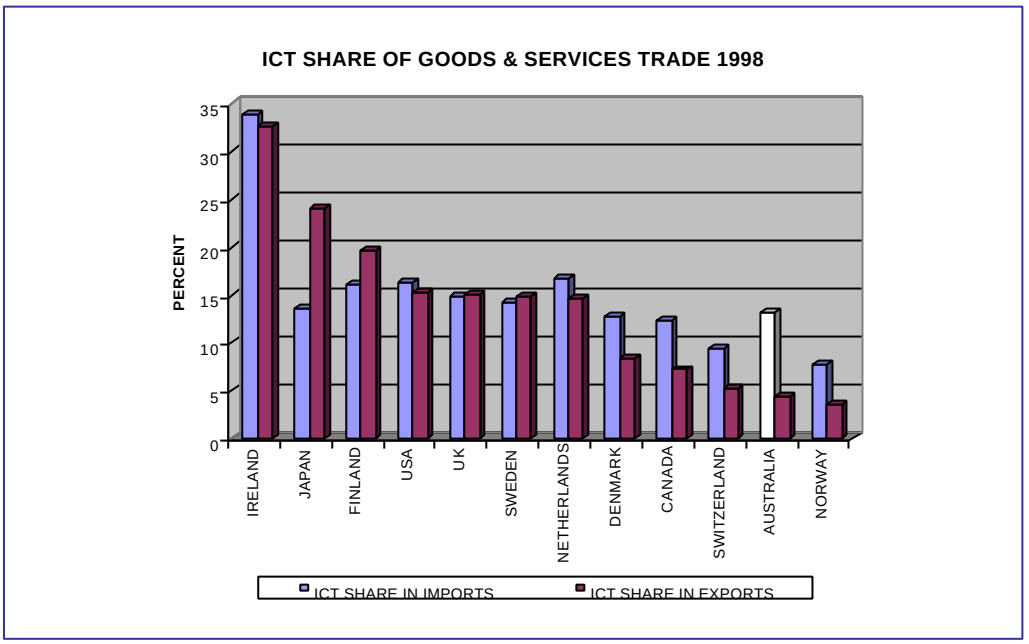
- Crude materials 18.9% of total exports in 1999-00.
- Mineral fuels 18.6%
- Food & live animals 17.3%

As Chart 8 shows, Australia's ICT trade performance (in terms of share of total trade) is very poor with ICT share of exports less than 5% compared with an import share of around 13%. Ranked by export share, Australia's performance places us 11th of the 12 nations for which data is available. Appendix 4 shows Australia has the 24th worst

[12] Sheehan P. and Tegart G. (1998) *Working for the Future: Technology and Employment in the Global Knowledge Economy*

export/import ratio in the OECD out of 28 countries for electronic industry goods and 20th worst for Office Machinery and Computers. These rankings were for 1997 and Australia's trade situation has **deteriorated further since then because Australia's exports of ICT goods has fallen 27% and imports have risen.**

Chart 8: Australia's ICT Share of Goods and Services Trade 1998



Source: OECD

The fundamental structural cause is shown in Australia's commodity trade and hence in the economy as a whole. Primary products for which international demand is growing relatively slowly dominate. In contrast, Australia's imports are dominated by industrial products, the demand for which is growing rapidly both domestically and internationally. ICT goods are a major group of industrial manufactured products and impact significantly on Australia's balance of payments.

Moreover, world prices for resource based commodities and products are falling vis-à-vis industrial manufactured product prices and therefore Australia's major exports are earning less per unit and imports are costing more. As a consequence Australia's terms of trade have fallen faster than in any other OECD country over the past decade.

4 ICT IN INNOVATION

Innovation and technological change are important drivers of economic growth and their importance is growing. ICT is unique in its capacity to underpin product and process innovation - and therefore productivity growth - across the economy, and in particular in the services sector. ICT has also:

- Shortened innovation and product cycles. For example computer simulations in pharmaceutical drugs development reduce the need for time-consuming testing.
- Stimulated greater networking in the economy - and globally. The complexity and cost of ICT developments are major drivers of cooperative arrangements, as is the evolution of communications services including the Internet.
- Played an important role in making science more efficient and linking it more closely to business.

> ***If I was going to design a policy for Australia to catch up, I'd want to have more R&D. I might do something like you did 10 years ago with Kodak, and give more subsidies to attract big (high-tech) investments here. I'd also try to develop your universities, because your universities aren't that strong. You need more international alliances with universities like Stanford or Harvard.***
>
> ***Dr David Hale, Global Chief Economist, Zurich Insurance Group***

ICT are the most critical of technologies because of their impact on the innovation process, for example new product creation, new product features, process improvement and the creation of systems for services right across the spectrum of industry. ICT also creates a new infrastructure for business, scientific research and social interaction which further stimulates innovation. It is difficult to imagine any area of economic activity which will not soon be highly ICT dependent.

The OECD has highlighted the impacts of ICT in the innovation process[13]:

- ICT breaks down natural monopolies in services such as telecommunications.
- ICT speeds up the innovation process and reduces product cycle times.
- ICT fosters greater networking in an economy.
- ICT allows faster diffusion of technology and ideas.
- ICT enables closer links between science and business to be forged.

Because new ICT capabilities are constantly emerging the opportunity for innovation is very high. In particular the Internet is stimulating greater ICT investment, making possible a sharp increase in the quality and functionality of existing ICT equipment. The low cost of connecting to the Internet and its independence from specific equipment or operating systems mitigates the opportunity costs of being locked on to a particular technology and reduces the "switching costs" to new technologies.[14] These developments increase the scope for innovation.

The outcomes of ICT research and development provide opportunities in many other industries for innovation (such as medical electronics, mining, agriculture, financial services and tourism). Australia must ensure it has the skill base and technological know-how to exploit these opportunities.

[13] OECD (2000), *A New Economy?* p47
[14] OECD (2000), *A New Economy*, p12

The need to address Australia's chronic ICT skill shortage was one of the most frequent comments made by stakeholders in submissions and during the Working Party's consultative forums.

The strategic importance of ICT research is reflected in the dependence on ICT of research in other fields. For example CSIRO has a direct expenditure of $30.5 million on ICT research but spends an additional $23 million on applying ICT to support research in its other fields of research. Cooperative Research Centres (CRCs) also have a strong reliance on applying ICT research to support their research with 26% of non-ICT CRCs identifying ICT related research as critical to their activities and another 26% indicating that it is significant[15]. Clearly the strength of Australia's ICT research and technology transfer infrastructure has wide ramifications for our capacity to innovate in other research fields.

Table 1: Distribution of CSIRO ICT Research & Development[16]

DIVISION	ICT RESEARCH FIELD
Mathematics & Information Sciences Telecommunications & Industrial Physics	ICT and service industries
Australia Telescope National Facility	Radioastronomy
Building Construction and Engineering	Construction & infrastructure planning
Exploration and Mining	Geoscience modelling & mine planning
Manufacturing Science & Technology	Manufacturing systems
Petroleum	Drilling decisions support
Molecular Science	Drug design
Atmospheric Research	Climate modelling
Agricultural Divisions	Farm decisions support

For example, innovation in biotechnology is highly reliant on ICT. The development of Relenza (a radical new 'flu vaccine) was heavily dependent on the use of high-performance computers for drug modelling and visualisation. Cochlear also continues its reliance on digital signal processing and Very Large Scale Integrated (VLSI) circuit miniaturisation in its product development process. Chart 8 illustrates this interdependence.

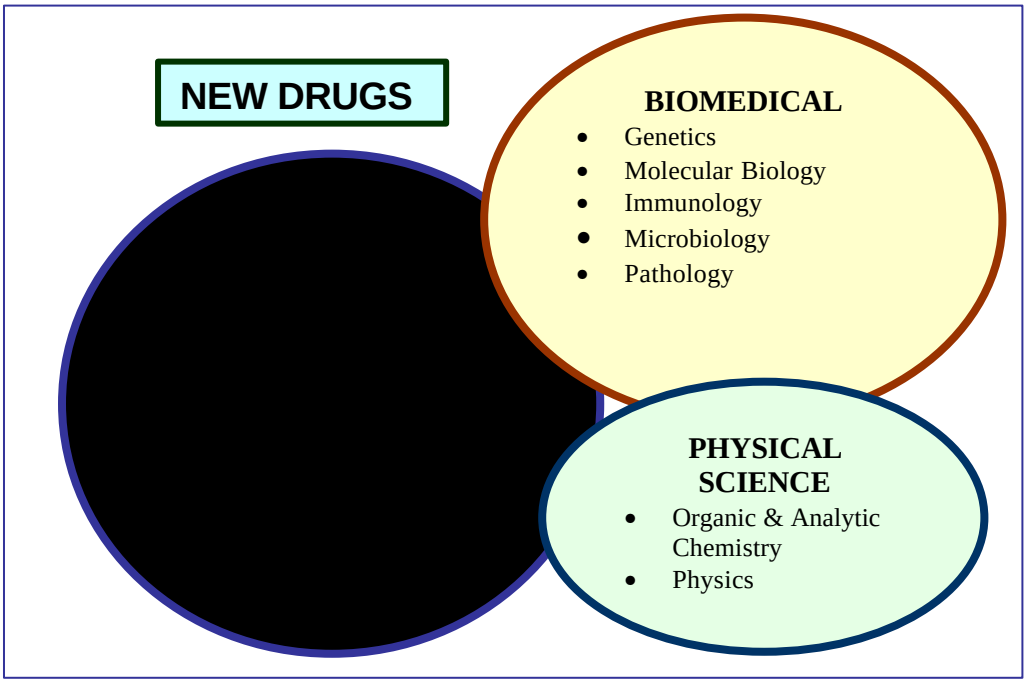
The opportunities for using ICT research are diverse and constantly expanding. Indeed, there are so many opportunities that some companies such as CISCO (network systems), Nortel (communications), Microsoft (software) and JDS Uniphase (optoelectronics) have taken to buying companies with new research based technology to complement their in-house research efforts.

Some companies are moving to identify new technologies that need incubation prior to commercialisation. In Australia, Ericsson has established an in-house incubator program (the 42nd Precinct) which serves as a test bed and market development hub for in-house IP as well as a "hotel" for start-ups and local companies to access design expertise and testing facilities.

[15] Communication from ISR.

[16] The classification is that of CSIRO. The Working Party would not have extended its definition as widely

Chart 9: ICT Underpins Biotechnology Research



Source: US Council on Competitiveness *Going Global: The New Shape of American Innovation*

5 AUSTRALIA IS A LEADING USER - IS THIS ENOUGH?

Australia will struggle to maintain its strong economic performance if we do not have a focussed effort to continually up-date Australia's domestic capacity in ICT innovation and production.

Future Performance

The primary factors, which impinge on our future performance, are:

- **Skills**

Australia's performance will only continue if it can maintain a broad base of information skills throughout the community and retain and reinforce Australia's high-end ICT skills capability. Close relationships between leading edge users and suppliers of ICT are important as are the skills to implement ICT innovations. There are serious issues facing Australia's ability to maintain the skills it needs which are discussed later in the report.

- **Being a first mover in using and developing ICT technology**

There is a “first mover” advantage in ICT which underpins the development of competitiveness across all industries, but particularly the Services industry. The OECD has concluded that the US has built its new economy advantage on the widespread “first mover” advantage it enjoys across information and communications technologies generally but particularly for Internet related technologies.

Australia's ability to capture some of the benefits of the ICT revolution in e-commerce and other Internet fields depends on the opportunities to establish “first mover” advantages through domestic innovation. This can be achieved by having lowest cost communications services but also experimental next generation networks on which products, processes and services can be developed, tested and proven.

- **Strong university-industry linkages**

Innovation in new economy sectors such as ICT relies heavily on interaction between users, producers and the science and research system. In ICT innovation the frontiers between science and its applications are blurring as fundamental discoveries can lead both to scientific publication and commercial products. Strong linkages between industry and government funded research are critical. Research projects and programs which achieve these linkages, while still allowing leading edge research to be undertaken, can be most effective.

Implications

The consequences of not maintaining strong ICT performance are:

- **Increasingly a price taker for ICT goods and services and deteriorating trade balance**

If Australia is only ever to be a purchaser of these technologies then it condemns itself to being a price taker and market follower for new and emerging applications and will miss out on significant shares of the economic rewards that come from the new technologies. Though old generation computer equipment is available almost at commodity prices, new generation hardware and software is more often sold at premium prices.

Australia's ICT trade deficit was around $9 billion in 1998-99 (approximately double wheat and wool exports), up 34% from $6.7 billion in 1996-97. This compares to Australia's overall balance of trade deficit in goods and services of $14.9 billion. The ICT trade deficit is equivalent to 60% of Australia's total trade deficit. While the scope for achieving a positive trade balance in ICT goods is limited (see Section 6) Australia can, as have many other countries, improve its exports substantially.

- **Vulnerable purchaser of ICT**

Even more significantly we may well lose the capability to be intelligent purchasers of ICT goods, let alone pioneers. Purchasing the right solutions cost-effectively requires detailed understanding of ICT, which can only come from having a critical mass of ICT-literate individuals, familiar with the technology through their involvement in research and development.

- **Falling capacity to integrate ICT with 'Old Economy' products and services**

ICT is becoming increasingly important to the international competitiveness of established products. Weakness in ICT research will reduce Australia's capacity to differentiate goods and services from those of competitors and weaken Australia's overall competitiveness and export performance.

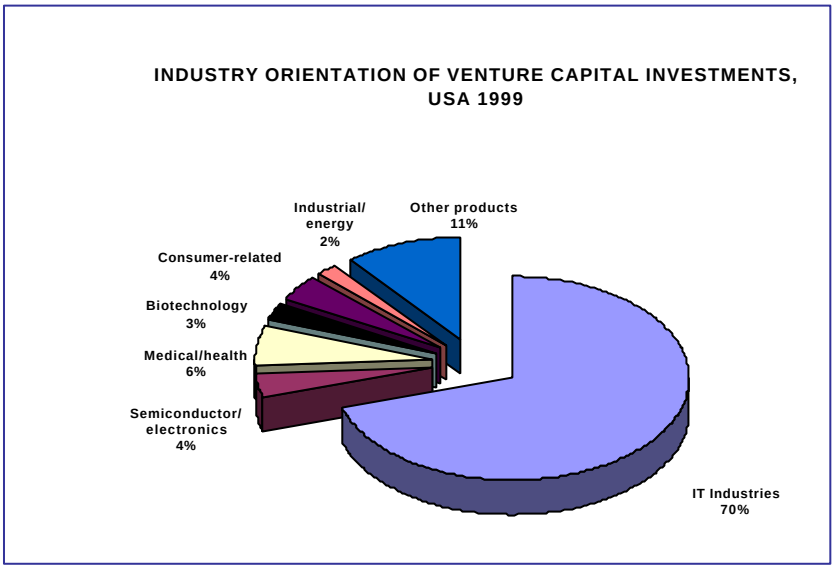
- **Missing significant opportunities for creating new tradeable goods**

The outputs of ICT R&D are tradeable in their own right and a source of significant export opportunities. Australia is missing out on the growth and trade potential achieved in those countries which have acted to take advantage of the unique opportunities emerging in ICT. In the past twenty years approximately 7 nations have emerged with significant shares of world ICT production.

The scope of opportunity is revealed in the proportion of venture capital directed to ICT companies. ICT industries (as opposed to industries using ICT) attract major streams of new investment.

In 1999, 70 % of all venture capital investments in the USA were in ICT industries as demonstrated in Chart 10.

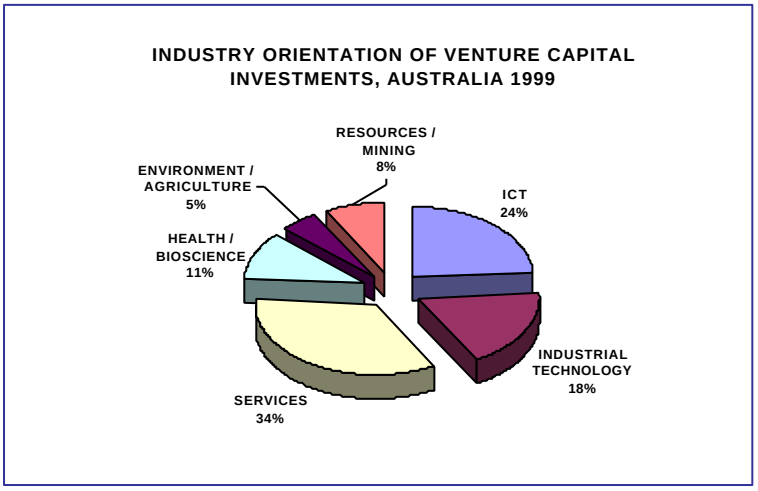
Chart 10: US Venture Capital Investments



Source: ***US National Venture Capital Association***

In contrast, ICT's share of venture capital in Australia is much lower (see Chart 11). However, the Australian investment proportions are not directly comparable because of differences in the classification of investments.

Chart 11: Australian Venture Capital Investments



Source*: Australian Venture Capital Journal*

What is pronounced in the Australian figures is the strength of funding of resources and services. Some of the investments such as in e-tailing (electronic retailing) are classified as services in the Australian chart but are treated as IT industries in the American chart.

The significance of the ICT industry as a wealth generator is further reflected in the rapid growth in world trade in ICT goods (around 10% pa between 1990 and 1996 – Chart 6), a growth rate that outstrips most other industries, particularly traditional sectors on which Australia has previously relied.

Ultimately, value creation comes down to having control or ownership of a scarce resource that is in strong demand. For Australia, one of the few ways that we can gain an increasing share of control or ownership of a significant scarce ICT resource that is in strong commercial demand is to invest in more R&D. This investment must occur in both the private and public sectors.

Conclusion

Australia needs to develop and maintain a solid level of scientific and technological capability in ICT R&D in order to create new products and adapt current products to meet specific requirements across all industries.

Exploitation of new technologies requires specific skill sets. Failure to successfully exploit ICT opportunities may be interpreted overseas as an indicator of potential weaknesses in other technologies. The implications of sending such signals could be significant in terms of Australia's ability to attract investment capital and high calibre researchers.