STRENGTHENING AUSTRALIA'S POSITION IN THE NEW WORLD ORDER

Working Group on Asia

Report to PMSEIC

June 2006

CHAIRMAN'S MESSAGE

The emergence of China and India brings with it many challenges, opportunities and threats to Australia – to our economy, our standard of living and our research and innovation system.

The working group has consulted with leaders from business, higher education and government about the implications for Australia. The message is clear: without a more systematic and strategic approach, Australian science and innovation capabilities will be washed over by the tidal wave of progress being experienced in China and India, and by the resulting global response.

China and India appear destined to regain their global economic clout over advancing decades. Aggressive science and technology investment by both governments could position these economies higher on the value chain in comparison with their trading partners.

China within the next decade, if the current trend continues, could become Australia's top trading partner with India rapidly coming up the ranks. They will have large markets with strong purchasing power and formidable science and technology capacities.

Like the rest of the developed world, Australia needs to respond proactively to the emergence of developing economies, which now make up half of the world's economy. As Australian industry is now making fundamental changes to remain competitive with China and India, so too must our science and technology system, its structures and researchers.

The working group calls for a three-pronged strategy to achieve this:

- Capture the opportunities emerging for Australian science and innovation
- Enhance our science and technology linkages with China and India
- Strengthen our science and innovation foundations for competitiveness.

Failure to do so could have serious consequences for Australia's future prosperity. We risk being marginalised by the emergence of these new economic superpowers. Without appropriate strategic actions, the tidal wave will take us in directions we may not want to go, and damage the capacity for Australia to maintain its strong growth and competitiveness. Today we stand at the brink of a new era – investing in our education and research base now will create new opportunities to build a technology-based Australian economy that is internationally engaged.

I would like to thank the members of the working group who have contributed many hours in attending meetings and drafting this report.

I look forward to the Government's consideration of our proposals.

Hutch Ranck

Chairman

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STRATEGIC GOAL

Position Australia to benefit from the rapid growth of China and India by strengthening Australia's science and technology capability and by increasing cooperation with these emerging economic superpowers.

Terms of reference

The growth of China and India has profound implications for Australia's own economic well-being. Recognising this, the Prime Minister's Science, Engineering and Innovation Council established the Working Group on Asia.

The working group was tasked with examining the growth of these two emerging countries as global economic and technological players, and providing advice to the Government on what this means for Australia. Specifically, our brief was to identify: **complementarities** between Australia's research and innovation capability and that of China and India; **threats** that the growth of these two countries may pose to our quality of life; and **opportunities** presented by the new global order. We were also tasked with recommending strategies for capturing opportunities to provide significant and sustainable benefits to Australia's own global position.

A new global order

The economic growth of China and India is not surprising when viewed in its historical context. These two countries dominated the global economy until the rise of European economies in the eighteenth century and that of the United States (US) in the twentieth century.

However the rapid economic growth of China and India in recent years has been remarkable. When compared on a purchasing power parity basis, China is now the world's second largest economy and is predicted to challenge the US for the number one spot within a decade.

The Chinese and Indian Governments are both committed to achieving advanced economy status through a 'leap frog' process.

In the period 1991-2004, total investment in R&D in China grew thirteen-fold. In the five years to 2004 China added 395,200 personnel to its researcher skills base, a 74 per cent increase. The number of higher education graduates grew 288 per cent between 1997 and 2004, 43 per cent of whom were in science and engineering fields. For 2004 China reported 644,106 degrees in engineering, computer science and information technology (for 2003 Australia reported 31,049).

Over the past decade India has demonstrated a similar pace of change, including passing the 1 per cent threshold for gross expenditure on R&D as a proportion of GDP in 2004. The number of universities rose from 209 in 1990 to more than 300 in 2005. Over a similar period, enrolment in higher education institutions rose from 4.9 million to 9.9 million, and science degree holders rose 60 per cent and the number of science postgraduates rose 50 per cent. In 2002 science and engineering accounted for 46 per cent of doctoral degrees earned in India, 13 per cent of which were in engineering and in 2004 India produced an estimated 215,000 engineering graduates.

The economic re-emergence of China and India is focussing the attention of all major economic powers. The US and the European Union (EU), as well as a number of individual EU countries such as the United Kingdom (UK), are responding decisively. For example, the US President's State of the Union Address this year outlined bold spending initiatives for non-defence research to ensure the US's competitiveness against the rise of China and India. These initiatives include: renewable energies; making the R&D tax credit permanent; and new funding for maths and science teachers. These initiatives involve expenditure of more than US$136 billion over 10 years.

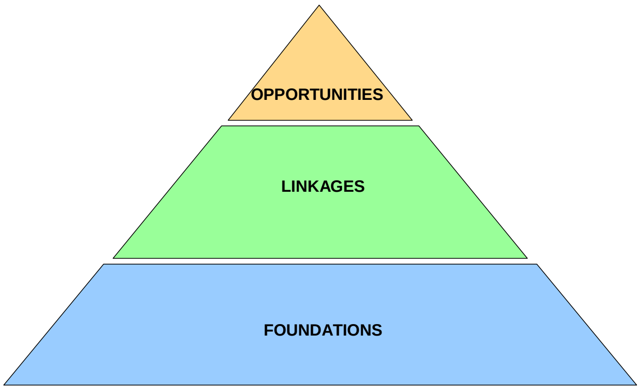
Australia needs to ensure that its science and technology system will be able to respond to the challenges of China and India, as well as other countries' responses, otherwise we will face erosion of our international competitiveness, given the critical role of science and technology for our future prosperity.

The re-emergence of China and India has highlighted how the sustainability of Australia's future prosperity will be more dependent upon our innovation capabilities for at least two reasons. First, Australia has benefited from high commodities prices and strong terms of trade, but inevitably as the commodity cycle turns, the economy will need other drivers to sustain growth. A failure to strengthen our science and technology capabilities and a hollowing out of our industrial capabilities (as is being experienced in manufacturing) will leave the nation vulnerable in the global marketplace.

Second, China and other developing economies are moving rapidly away from being low value, low labour cost producers of goods and services to sophisticated and globally competitive producers of technically complex and elaborately transformed goods and services. This is the real threat that Australia, together with other developed countries, faces in maintaining growth and competitiveness.

The Australian response to these challenges should be to move quickly to strengthen our economy and build technology-based export oriented manufacturing and services. We have the capability and expertise to build strong businesses in knowledge based niche areas. These businesses can draw on the skills and inventiveness of our population and provide quality jobs for the future.

Our working group offers the Government a strategy for responding to the challenge and opportunity from the strong growth of these global economies. The working group makes three overarching recommendations, supported by a number of specific actions. We have adopted a three-tiered approach to the report and recommendations as the following pyramid illustrates. To take advantage of the opportunity, we need to build stronger links with China and India and leverage our strengths to address the needs of these countries. We also need to ensure we have a solid foundation in education, science and technology together with a business environment that encourages business formation and expansion. The stronger links will provide a basis for close and productive economic relationships with China, India and other developing nations in Asia.



Capture the opportunities

The economic growth of China and India presents significant opportunities for the Australian economy. This was acknowledged by the Prime Minister at a business luncheon in New Delhi in March 2006, when he observed that the growth of China and India had shifted the epicentre of the world's middle class to Asia, with enormous implications for Australia.[1] The rapid expansion in domestic and foreign investment in Chinese and Indian R&D capability offers opportunities for Australian researchers and industry, particularly in four priority areas identified by the working group, namely energy, water, agriculture and health (for additional information about the process for identifying these priority areas see Appendix 7), as well as the emerging areas of interest in biotechnology, medical devices, engineering design and animal health.

The challenge, however, will be to capture these opportunities given that Australian industry is dominated by small to medium sized enterprises, with relatively low R&D intensities. It is difficult for these businesses to gain traction in export markets. A small domestic market means many of the SMEs must export in order to grow. Our R&D system must support this export growth. It is clear we are coming from a low base. At 0.33 per cent of GDP, Australia's expenditure by government research agencies on R&D ranked eighth among OECD countries in 2002, compared to the OECD average of 0.25 per cent.[2] By contrast, at 0.89 per cent, Australian business expenditure on R&D as a proportion of GDP was well below the OECD average of 1.15 per cent, ranking eighteenth.

The Australian Bureau of Statistics innovation survey has outlined the level of collaboration between public and private sectors in Australia, an area that often has been signalled out either for improvement or in need of improvement.[3] To improve our environment for innovation, the working group recommends that the Government facilitate Australian private sector investment in R&D by supporting public-private R&D partnerships, and that this becomes an essential element of funding and evaluation of public sector research organisations.

The Productivity Commission is undertaking a research study into the economic, social and environmental returns on public support for science and innovation in Australia. This study has the potential to "guide the allocation of funding between and within the different components of Australia's innovation system"[4] and ensure Australia's financial incentives for R&D remain competitive with other OECD countries. To be effective, financial incentives have to involve minimal compliance costs, and any excluded areas need to be clearly defined.

The working group has identified two broad areas where Government support would make a significant contribution to preparing Australian industry to capture the opportunities offered by China and India, namely increasing the uptake of science and technology by Australian industry and encouraging innovation strategies that enhance linkages between Australian and Chinese and Indian R&D.

> With a strong investment in education and an encouraging business environment, our researchers and engineers will capture the increased opportunities that closer relations with China and India will afford.

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[1] Prime Minister of Australia; *Transcript Of The Prime Minister The Hon John Howard MP Address To The Business Luncheon, Diwan-I-Am Room, New Delhi* [on-line]; available from http://www.pm.gov.au/news/speeches/speech1808.html; Internet; accessed 6 March 2006

[2] Commonwealth of Australia; *Australian Science and Technology at a Glance*, Department of Education, Science and Training, December 2005: p. 33

[3] Australian Bureau of Statistics, *8158.0 - Innovation in Australian Business, 2003* [on-line]; available from http://www.abs.gov.au/ausstats/abs@.nsf/5f1e01afb32859f9ca25697500217f48/222bd10c221fbabbca256faa007bb1fe!OpenDocument; Internet, accessed 3 April 2006

[4] The Hon. Julie Bishop MP, *Productivity Commission to Review Public Support for Science and Innovation* [on-line]; available from http://www.dest.gov.au/Ministers/Media/Bishop/2006/03/B004100306.asp; accessed 13 March 2006

The level of R&D funding is not the only measure. We must consider effectiveness and efficiency and whether we are creating and exploiting marketable intellectual property.

"The main challenge … is not about how to increase the supply of commercial ideas from the universities into business. Instead, the question is about how to raise the overall level of demand by business for research from all sources."[5] Excellent science does not automatically result in innovation. We tend to use science and innovation in the same breath, but they are not interchangeable. The engineering process and subsequent development of the technology is actually the start of the commercialisation process.

To capitalise on the opportunities arising from the rapid growth of India and China, Australia needs to build a stronger business research base, improve our environment for innovation and encourage R&D that addresses the highest priority needs of China and India in areas where we have global strength. Based on the working group's extensive consultations we believe that the greatest opportunity for sustainable growth lies in focusing on those areas of priority need for China and India where we have world class capability - energy, water, agriculture and health.

Recommendation 1

Australia needs to capture the opportunities created by the emergence of China and India by encouraging business engagement in our four priority areas, stimulating business investment in R&D, and simplifying private company access to publicly funded intellectual property.

Enhance the linkages

For Australia to improve its international standing we must be fully engaged with the global economy.

Australia enjoys good people-to-people links with both China and India, and has the beginnings of good government-to-government relations. High level bilateral links enhance Australia's visibility and status within those countries. Government level agreements, high level government and industry delegations and joint funding programmes for collaboration all build stronger links. There was a clear government role in arranging the Liquid Natural Gas deal between Australia and China, which will bring $25 billion into Australia over 25 years.

Australia recently hosted a visit by Chinese S&T Minister Xu Guanhua and senior officials from the Ministry of Science and Technology and the Chinese Academy of Sciences. It provided an excellent opportunity for showcasing Australia's strengths in areas of common interest. Similarly, the visit to India this year by Prime Minister Howard and the accompanying industry delegation provided an important boost to our profile in that country.

Australia is competing for attention against all other global players. Other OECD countries are making a much greater effort to develop science and technology-based links with China and India (see Appendix 4). Clearly we cannot compete on scale but we must significantly improve our investment in these relationships if we are to make an impact.

Australia must have a consistent and transparent whole-of-Government strategy that drives increased collaboration in ways that ensure that all activities and interactions with China and India are coordinated and effective.

[5] HM Treasury; *Lambert Review of Business-University Collaboration, Final Report*; December 2003; p. 3

Nor should we try to develop collaboration across the board. We must focus. By identifying where our comparative strengths coincide with the emerging needs of China and India, the working group has articulated priority areas for collaboration as energy, water, agriculture and health (see Appendix 7), as well as emerging areas of interest as biotechnology, medical devices, engineering design and animal health. These need to be supported with significant resources.

To meet the challenge and opportunities provided by the rapid development of science and technology in India and China, Australia needs to dedicate a significant investment to promote and strengthen links in education, science, technology and technology-related business and build on recently announced initiatives.

Recommendation 2

Australia needs to enhance the linkages with China and India by developing a whole of government strategy for engagement and by investing in collaborative knowledge infrastructure.

Strengthen the foundations for competitiveness

When the working group started, we focused on business opportunities and threats. But during our deliberations and interactions, we unanimously came back to the same premise – without a strong education foundation no strategy is sustainable.

The rise of China and India as global technological players threatens nations traditionally reliant on knowledge capital for their prosperity. A revolution in information and communications technology and liberalisation of trade, has facilitated a massive transfer of business processes and investment in production from the developed to the developing world, accelerating throughout the last decade. Australian firms are now looking overseas for a number of their business inputs – including some R&D, components for manufactured goods and overseas investment. By sourcing these inputs from overseas, some Australian companies have improved their international competitiveness and increased their exports.

Australia is a small nation, lacking the scale and industrial structure to compete on a level footing with the major economies across all sectors. But our successes show that we can excel at the highly creative end of the process. Our wine industry, which is technology-based, is achieving exports of $3 billion per annum. This inventiveness is recognised and valued by our global partners, and our competitive resource extraction and delivery remains Australia's predominant strength. Survival in the new world order will depend upon our turning that capacity to innovate into economic prosperity on a much larger scale. We must strengthen the foundations for competitiveness.

The prognosis is alarming. Significant skill shortages are occurring in the science, engineering and technology (SET) fields, particularly engineering, earth sciences, chemistry, spatial information science, entomology, mathematics and statistics. These shortages are predicted to worsen in the face of declining or stagnant enrolments in SET fields at all levels of education, increased demand for skills in engineering and the enabling sciences resulting from economic development and increasing global demand for highly skilled labour.[6] In higher education, domestic enrolments in SET courses as a proportion of total enrolments, has declined from 15.8 per cent in 1989 to 14.0 per cent in 2004. Much of the decline occurred in engineering, agriculture, environment and related studies, while the proportion in natural and physical sciences has remained static. Not only do we not have the capacity to improve our position as a knowledge economy, our ability to sustain our current position is doubtful.

[6] Paul Mills, Director, Skills Analysis Section; DEST, presentation to the working group, 19 September 2005

In 2004, in response to growing disquiet in the US about the loss of highly skilled jobs to developing countries, McKinsey undertook the first comprehensive analysis of global supply and demand for talent and its impact on the global marketplace. This study found that despite the rapid growth in graduate numbers in China and India, their ability to satisfy demand at the quality end of the market is still a considerable way off.[7]

Australia must take urgent steps to strengthen the foundations for S&T essential for our future competitiveness.

Commonwealth grants to universities from 1996 to 2003 increased by 6 per cent in seven years; from $4.6 billion to $4.9 billion. Student to staff ratios are often cited as another key quality input benchmark. Between 1993 and 1999, staff numbers in universities rose by only 1 per cent while student numbers rose by 19 per cent. Consequently, student/teacher ratios rose substantially, from 14.2 in 1993 to 18.3 in 1999. Academic staff numbers began to rise again in 2000, but student/teacher ratios continued to increase until 2003, reaching 20.1 in 2003 before falling in 2004 to 19.8.

Recent funding increases, including *Backing Australia's Ability* initiatives were a welcome contribution and have made a positive impact. However, the universities need substantial funding to address their global competitiveness and capture opportunities. They need this funding to build world class infrastructure to attract the best researchers in their field; to support the best possible teaching at our universities; and to ensure they have the most technologically advanced teaching and research support. In particular, Australia needs to urgently re-invest in science and engineering, and challenge our universities to use these additional funds to improve their international standing.

We also need to improve teacher training and qualifications and increase school level participation in science and mathematics.

We need to build on *Backing Australia's Ability* and *Backing Australia's Ability - Building our Future through Science and Innovation*, to raise the quality of Australia's education system, to generate the skills needed to take a global leadership role in science, technology and engineering and support our schools and teachers to meet this challenge.

Recommendation 3

Strengthen the foundations of Australia's education system by increasing the investment in higher education, attracting higher quality Australian students into science and engineering, strengthening the science and maths teaching and curricula in Australian schools, and attracting higher quality doctoral students from China and India.

[7] Diana Farrell, *The Emerging Global Labor Market: Part 1 – The Demand for Offshore Talent in Services*; McKinsey&Company; June 2005

CHAPTER 1 A NEW GLOBAL ORDER

This chapter examines Australia's current trading relationship with China and India; it outlines trends in investment in R&D and education in China and India; it considers longer term global power shifts; and analyses trends in manufacturing, services and the globalization of R&D. These rapid changes pose both threats and opportunities. The responses of other governments to these changes are discussed, including the impact on global competition for talent. The chapter concludes with an examination of the implications for Australia, and the challenge for Australian firms which need to compete in the global economy.

Shifting global economic balance

The rapid economic growth of China and India in recent years has been remarkable. When compared on either a purchasing power parity basis or market exchange rate basis, China can be considered either the world's second largest economy or the world's fourth largest economy respectively and is predicted to challenge the US for the number one spot within a decade.[8] In the period 1991-2004, total investment in R&D in China grew thirteen-fold. In the five years to 2004 China added 395,200 personnel to its researcher skills base, a 74 per cent increase. The number of higher education graduates grew 288 per cent between 1997 and 2004, 43 per cent of whom were in science and engineering fields.[9] For 2004 China reported 644,106 degrees in engineering, computer science and information technology[10] (for 2003, Australia reported 31,049).[11]

Over the past decade India has demonstrated a similar pace of change, including passing the 1 per cent threshold for gross expenditure on R&D as a proportion GDP in 2004.[12] The number of universities grew from 209 in 1990 to more than 300 in 2005.[13] In 2004 India produced an estimated 215,000 engineering graduates.[14] During the 1990s student enrolment in higher education institutions rose from 5.2 million in 1991-92 to 7.7 million in 1999-2000.

[8] Saul Eslake, *China and India in the world economy – and implications for Australia*; Chief Economist, ANZ Bank; presentation to the working group; 11 November 2005

[9] Ministry of Science and Technology of the People's Republic of China*, S&T Statistics Data Book (2005)/S&T Statistics Data Book (1998)* [on-line], available from http://www.most.cn/eng/statistics/; Internet; accessed 10 April 2006

[10] Ministry of Education of the People's Republic of China*, Number of Students in Regular HEIs by Field of Study* [on-line]; available from http://www.moe.gov.cn/edoas/website18/info14477.htm; Internet; accessed on 10 April 2006

[11] Australian Government, Department of Education, Science and Training, *Students 2004 (First Half Year): Selected Higher Education Statistics* [on-line]; available from http://www.dest.gov.au/sectors/higher_education/publications_resources/statistics/publications_higher_education_statistics_collections.htm#studpubs; Internet; accessed on 10 April 2006

[12] *UNESCO Science Report 2005*, United Nations Educational, Scientific and Cultural Organization Publishing; 2005; p. 245

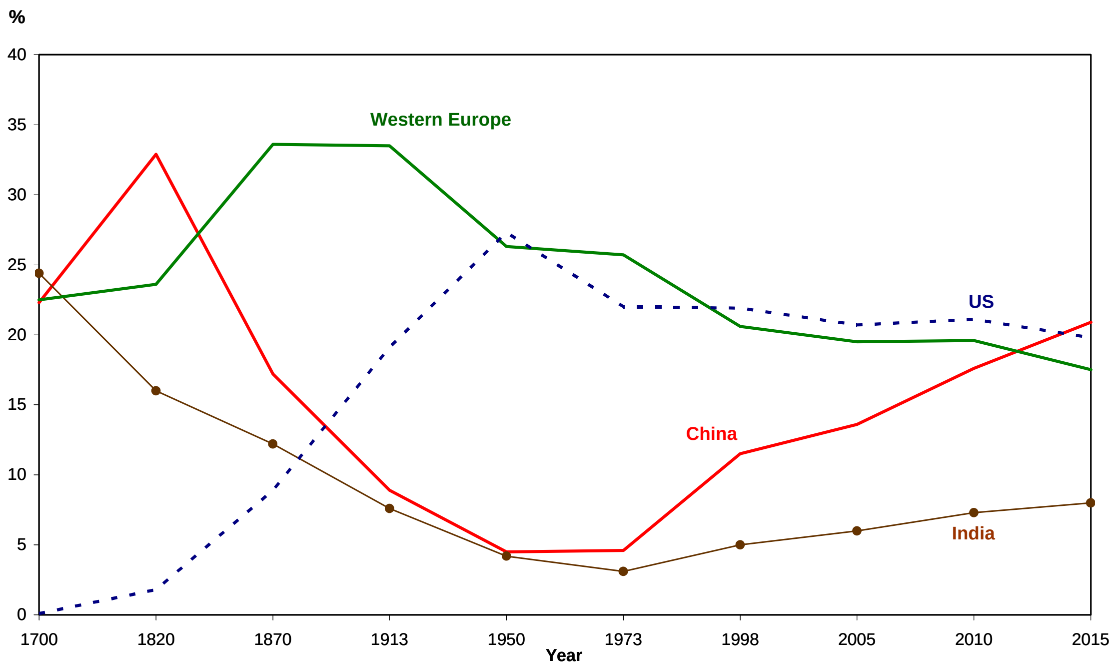
[13] ibid.

[14] NASSCOM, *Strategic Review 2005: Chapter 6: Sustaining the Indian Advantage* [on-line]; available from http://www.nasscom.org/strategic2005.asp; Internet; accessed on 10 April 2006

China and India have historically been major contributors to the world economy. Figure 1 below shows a dramatic rebalancing of the global economic order. It builds on OECD data coupled with some forecasts for the next decade. The predictions represent a consensus of the world's top economists. China is predicted to pass the US as the world's biggest economy by 2015, with India taking third place.[15]

The drivers of this change of position include the transition of China to a free market economy, the global movement of information, and the urbanisation of these populous countries. This presents both threats and opportunities for Australia. The opportunities lie in working with both countries to address key needs and opportunities that will enable and sustain their ongoing growth. The threat is that, in the near future, with the exception of those parts of Australia's economy which are based on our 'natural bounty' and jobs that require physical proximity, all other products, services and jobs will be exposed to increasing global competition from other countries, especially China and India.

Figure 1: Share of world GDP, 1700-2015AD



Source: Adapted from chart provided by Economics@ANZ, based on data from Angus Maddison, *The World Economy: A Millenium Perspective,* OECD Development Centre, 2001; IMF, *World Economic Outlook Database,* September 2005; Consensus Economics, *Consensus Forecasts,* October 2005

[15] Eslake, *China and India in the world economy*; loc. cit.

Our trading relationships

China's rapid growth has had a positive impact on the Australian economy by driving up both demand and prices for our primary exports, keeping us buoyant in the face of other adverse global events. But Australia's trade performance is still dependent to a significant degree on the export of natural resources, which has a history of cyclical swings in supply/demand and pricing. In order to achieve sustained prosperity we must provide avenues for Australia to develop increasing trade in energy and high-end knowledge based products and services. Through the application of science and technology to our natural resource exports, we can attract premiums and sustain markets. Australia must position itself in the highest value areas of quality, innovation and design in such sectors as education, medicine, biosciences and engineering.

Australia's global trade position is worsening. Our global trade deficit increased from $6.6 billion in 2000 to $23.4 billion in 2004, before falling to $16.9 billion in 2005, mainly on the back of strong resources prices. Over the last five years our exports of manufactured goods have fallen by an average of 0.4 per cent per annum, while our imports of manufactured goods have averaged 5.2 per cent growth per annum. The ability to reverse this trend lies in part in the potential for expansion of our bilateral relationships with China and India. We can enhance our economic relations with both countries if the recommendations in this report are adopted.

The working group, with input from various government agencies and other organisations (see Appendix 13) identified energy, water, agriculture and health as key potential growth areas for Australian service providers (for additional information about the process for identifying these priority areas see Appendix 7). It also identified biotechnology, medical devices, engineering design and animal health as emerging areas of interest. A report released in April 2006 by the Minister for Communications, Information Technology and the Arts, identified significant opportunities in emerging markets including China and India for Australian software in niche industries associated with education, energy, government, health, manufacturing and minerals.[16]

[16] Senator The Hon. Helen Coonan, *New ICT report demonstrates growth opportunities* [on-line]; available from http://www.minister.dcita.gov.au/media/media_releases/new_ict_report_demonstrates_growth_opportunities; accessed 3 April 2006.

China

As Figure 2 below shows, our trade relationship with China is strengthening. In 2004-05 China overtook the United States to become Australia's second largest merchandise market, with the value of bilateral trade quadrupling over the past decade. In 2005, two-way merchandise trade increased by 29 per cent to $37.3 billion dollars. The value of our merchandise exports climbed by 46 per cent to $16 billion, with key resource products leading the way - iron ore up 126 per cent to $5.7 billion, copper ores up 226 per cent to $628 million, other ores up 49 per cent to $582 million and coal up 27 per cent to $530 million. Our second biggest export item, alumina, is a confidential item (we exported more than $1.5 billion of alumina in both 2003 and 2004). Our third biggest export item, wool, grew by a modest seven per cent in 2005 to $1.3 billion. Merchandise imports from China increased by 19 per cent in 2005 to $21.3 billion (led by clothing, computers, footwear, toys and games). Our bilateral trade deficit with China fell in 2005 for the first time since 2001 (down from $6.9 billion in 2004 to $5.3 billion); resources (energy and minerals) accounted for nearly 64 per cent of our merchandise exports and if you include value add downstream products such as tubes, coils and wires, they accounted for 73% of merchandise exports.

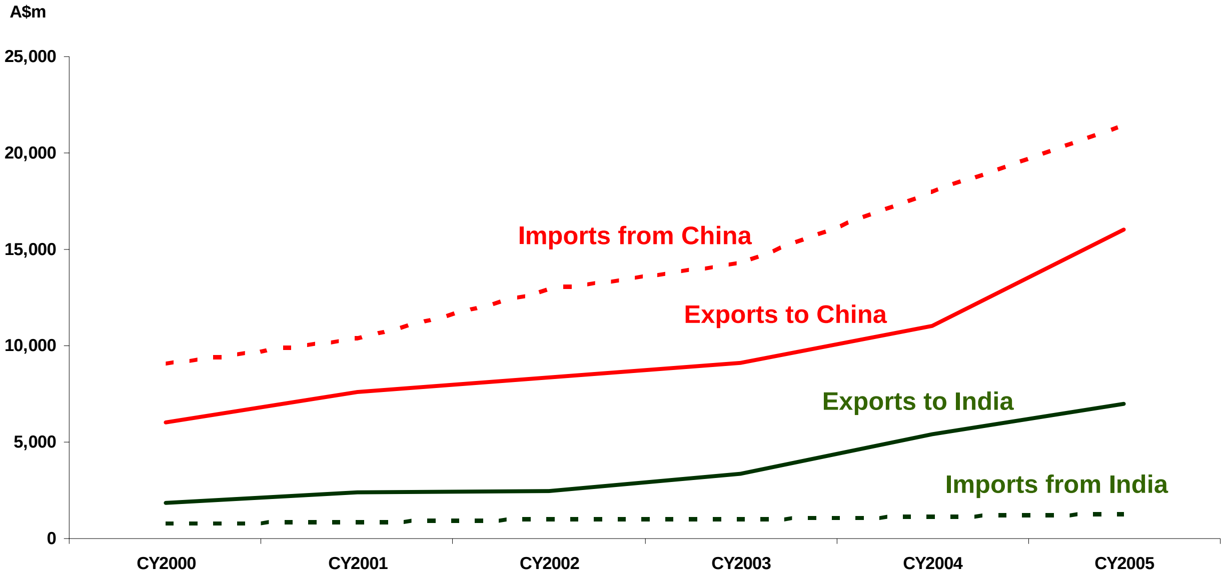
China is Australia's fifth largest and fastest growing market for services. Our services exports grew by 15.2 per cent in 2005, up from $ 2 billion in 2004 to $2.4 billion. Annual growth in our services exports has averaged 14 per cent over the last 5 years. There are currently more than 80,000 Chinese enrolments in Australian educational institutions. China (including Hong Kong) was the single largest source country for international students in 2005, accounting for almost 30 per cent of total enrolments. Students originating from mainland China, Taiwan, Hong Kong and Macau studying in Australia contributed about $2.559 billion in 2005, an increase of 18% over 2004. Tourism is also booming. Nearly 285,000 Chinese tourists came to Australia in 2005, a 13.4 per cent increase on the previous year. The Tourism Forecasting Committee has calculated that China will become Australia's fastest growing tourism market over the next decade, with 16.5 per cent average annual growth (to around 1.13 million visitors per annum by 2014).

China is currently the 17th largest foreign investor in Australia, with just under $2.0 billion of total investment in 2004 (mostly in resources and property). But Chinese investment appears to be increasing with several big investments, such as ChemChina's purchase of plastics manufacturer Qenos and the Chinese Aluminium Company (Chalco) bid for the significant Aurukun bauxite deposit in North Queensland, taking place over the last 18 months.

The Australia-China Free Trade Agreement offers an opportunity to further reduce trade barriers, streamline regulatory requirements and improve mutual recognition of professional qualifications to boost trade in professional services. An FTA will protect and promote Australia's competitive position in the Chinese market as well as facilitate investment in China. Independent modeling suggests that an FTA with China could add up to $24.4 billion to Australia's real GDP over a ten year period.[17]

[17] Peter Jennings, *Getting China Right: Australia's policy options for dealing with China*; Australian Strategic Policy Institute, 2005

Figure 2: Australia's merchandise trade with China and India



Source: Based on data from Market Information and Analysis Section, DFAT

India

As Figure 2 above shows, our trade with India is not yet as significant as that with China, but it's growing rapidly. India is currently Australia's twelth largest merchandise trading partner. In 2004-05 India overtook the UK and Taiwan to become our sixth largest merchandise export market. India has grown faster than any of our other top thirty markets over the past five years. In 2005, two-way trade in goods totaled around $8.2 billion, $7 billion of which was Australian exports to India.

The trade relationship is dominated by merchandise (particularly gold which represents about 43 per cent of our exports to India), although the role of services is growing. Australian export of services rose by about 39 per cent in 2005 to $937 million. While this represents only 2.5 per cent of total service exports, new prospects are emerging in ICT, education, tourism, health, film and financial services. India is our twenty first largest source of service imports, which were worth about $286 million in 2005 (but have grown by about 8 per cent over the last five years). Indian investment in Australia is also worth around $1 billion, making Australia the ninth most important destination for Indian foreign direct investment.

Implications for Australian manufacturing and services

Our manufacturers have already been experiencing the competition arising from China's and India's growth. In the last five years exports of manufactured goods have fallen by 0.1 per cent per annum while imports of manufactured goods have averaged 5 per cent growth per annum. In the last 10 years employment in Australia's manufacturing sector has dropped by 4.5 per cent. However, manufacturing share of total employment dropped from 13.4 per cent in 1996 to 10.6 per cent in 2006. In 1980 less than 10 per cent of manufactured exports were produced in developing economies. China now accounts for more than 8 per cent of worldwide value added manufacturing. In 2005 China produced half the world's digital cameras, about 25 per cent of major kitchen appliances and 37 per cent of computer hard drives. Recent patent applications show a similar trend. For example, in 2003 China accounted for 12 per cent of world patent applications in nanotechnology (ranking third behind the US and Japan),[18] and in 2002 China ranked fourth in biotechnology patent applications as a percentage of the national total (behind New Zealand, Denmark and Australia).[19]

However Australia is seeing growth in the area of services. In 2004-05 total trade in services was worth $75 billion (see Figure 1.4 Appendix 1). This represents an increase of 29 per cent over the previous five years. Tourism, transportation and education accounted for 73 per cent of the growth in service exports over that period.

The response of China and India

We should have no doubt about the resolve of the governments of China and India to develop knowledge based economies and move from their current status as predominantly low cost manufacturing nations. From 1991 to 2003 Chinese investment in R&D grew by a factor of eight. This year China's State Council announced that it will increase investment in R&D to US$112 billion by 2020, doubling the proportion of China's GDP spent on research and development from today's 1.3 per cent to 2.5 per cent. The country's reliance on foreign technology will drop to below 30 per cent compared to more than 50 per cent today.[20]

As Treasurer Peter Costello told the Lowy Institute in September 2005 "The economic rise of China – and, in coming years, of India – will be the dominant narrative of the world economy in the years ahead".

According to the OECD, China has become the third largest R&D performer behind the United States and Japan, with the second largest number of researchers (862,000). This is set to rise sharply as a result of Chinese investment. China turned out 885 000 university graduates in 2002, of which almost 15,000 were awarded a PhD degree. This number jumped to 19,000 in 2003.[21]

India is also making rapid progress in developing a knowledge based economy, particularly in areas such as information technology and health/biosciences, with India now projected to approach 10 per cent of the world's GDP in 2015.

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[18] CHINA daily, *China's nanotechnology patent applications rank third in world* [on-line]; available from http://www.chinadaily.com.cn/en/doc/2003-10/03/content_269182.htm; Internet; accessed on 26 April 2006

[19] OECD, *Compendium of Patent Statistics*; OECD 2005; p. 21

[20] Embassy of the People's Republic of China in the United States of America, *China strives to be one of world's science powers* [on-line]; available from http://www.china-embassy.org/eng/xw/t234561.htm; Internet; accessed on 9 February 2006

[21] OECD, 2005, *Science, Technology and Industry Scoreboard*, Paris

India and China are using science, technology, innovation and education to drive the growth of their economies.

Growth in China and India is in part driven by investment from developed countries, particularly the US, Germany, UK and France. Some high profile examples for India include: General Motors has invested $21 million in their science laboratory in Bangalore, and DaimlerChrysler conducts applied research and software development at the DaimlerChrysler Research Center India.[22] Furthermore, in India Microsoft, Intel and Advanced Micro Devices will spend nearly US$6 billion on research and manufacturing over the next few years. Examples for China include: the Semiconductor Manufacturing International Corporation (from Taiwan) investing $2 billion in Shanghai's Zhangjiang High Technology Park , and NVIDIA Corporation (ranked second in the world for chip design) and Marvel Semiconductors Inc (ranked eighth) investing $14 million in Zhangjiang. Foreign pharmaceutical companies, including Astra Zeneca, Roche and Eli Lilly, are investing significant funds in joint research with Chinese institutes within the biotechnology sector of Zhangjiang.[23]

These examples reflect a broader trend. Business enterprises are globalizing their R&D in the same way that they have been globalizing some manufacturing and services. Increasingly businesses are locating facilities or establishing partnerships in China and India. McKinsey reports that businesses in the US currently undertake up to a third of their R&D overseas (including in Australia), while continuing to keep the most sensitive and strategic elements close to corporate headquarters.

Global demand for skills

The global demand for science, engineering and technology skills is expected to intensify.[24] In the US, demand for such skills is expected to continue to exceed supply, resulting in an ongoing need to recruit people with these skills from other countries, including Australia. At the same time, the European Union announced plans to increase expenditure on R&D to 3 per cent of GDP by 2010. If these plans were achieved, this would create a demand for about one million additional workers with science, engineering and technology skills.

In spite of rapid growth in the numbers of graduates being produced by universities in China and India there are indications of skills shortages in those countries too. For example, China is actively recruiting expatriates in order to provide leadership in its rapidly growing research system. 81 per cent of the members of the Chinese Academy of Sciences and 54 per cent of the Chinese Academy of Engineering are returned overseas scholars.[25] All of these factors are expected to put pressure on the world supply of science, engineering and technology skills.

China and India have enormous pools of highly talented people. China, and increasingly India have well-resourced and equipped universities and research facilities. Building stronger science and technology-based alliances with these countries can provide Australian researchers and companies with access to facilities and ideas that enhance our own competitiveness.

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[22] Diana Farrell, *The Emerging Global Labor Market:* op. cit.; pp. 76 - 77

[23] The Allen Consulting Group, *The Role of S&T Parks in Asia's Economic Growth*, July 2005, pp. 67-68

[24] The Allen Consulting Group, report to DEST, 2006

[25] Ping Zhou and Loet Leydesdorff, *The Emergence of China as a leading nation in science*; Elsevier; 9 November 2005

In order to be competitive as an economy, and to have the science and business capabilities to make us an attractive partner to China and India, Australia needs to strengthen its science, education and business base and to capitalise on good people-to-people and government-to-government relations which can help make us a favoured nation for collaboration. Not to do this will result in our being marginalised by the emergence of these new economic superpowers.

Today we stand at the brink of a new era – investing in our education and research base now will create new opportunities to build a technology-based Australian economy that is internationally engaged.

In the US a major report by a Senate Committee, chaired by former Lockheed Martin Chief Executive Officer Norman Augustine, has recommended the following actions in response to what it sees as emerging threats from China and India:

- Increase investment in education, including annual recruitment of 10,000 science and mathematics teachers by awarding 4-year scholarships, and programs to strengthening the skills of 250,000 teachers
- Increase federal investment in long-term basic research by 10 per cent a year over the next seven years, Establish an Advanced Research Projects Agency in Energy and institute a Presidential Innovation Award
- Increase the number of US citizens pursuing graduate study in “areas of national need” by funding 5,000 new graduate fellowships each year, providing a one year automatic visa extension to international students who receive doctorates in science, technology, engineering, mathematics, or other fields of national need enabling them remain in the US to seek employment
- Enact a stronger R&D tax credit to encourage private investment in innovation.[26]

In response to the Augustine report, President Bush announced in his State of the Union Address in January, an American Competitiveness Initiative.[27] If approved by Congress it will encourage American innovation and strengthen the US’s ability to compete in the global economy, particularly against China and India.

The Initiative would commit $5.9 billion in FY 2007, and more than $136 billion over 10 years, to increase investments in R&D, strengthen education and encourage entrepreneurship and innovation. The President’s strategy includes doubling the Federal commitment to critical basic research programmes, encouraging additional private-sector investment in innovation, improving the quality of maths and science education, and supporting universities that provide world class education and research opportunities.

Australia cannot compete on volume. We can compete if we are targeted, strategic and engage in real collaboration – not to act will have clear dire consequences under the tidal wave of activity from China and India.

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[26] Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* National Academies Press; 2005; pp. ES2 - ES7

[27] The White House, *American Competitiveness Initiative* [on-line]; available from http://www.whitehouse.gov/stateoftheunion/2006/aci/; Internet; accessed on 11 April 2006

CHAPTER 2 CAPTURE THE OPPORTUNITIES

This chapter examines what needs to be done for Australia to capture benefits from the growth of China and India. It reviews the contribution of science and innovation to business competitiveness, the importance of stimulating business R&D and a description of how Australian business could harness the forces of globalisation arising from the growth of China and India.

Science and innovation enhances business competitiveness

The economies of China and India offer enormous potential for Australian business. This was acknowledged by the Prime Minister at a business luncheon in New Delhi in March 2006, when he identified that the growth of China and India had shifted the epicentre of the world's middle class to Asia, with enormous implications for Australia.[28] Given the emphasis of China and India on technology-driven economic growth, Australia has the opportunity to build on its political standing and use our strengths in science and technology to build much stronger research and business relationships. This will benefit Australia's science, business and economy.

Australia needs to invest more in our knowledge based companies in order to help them leverage connections with China and India. The globalisation of production, including the production of knowledge, is now an established fact.

We have a unique opportunity to build on our position of strength in natural resources, to extend our capability to meet China's and India's highest priority needs in key areas such as energy, water, agriculture and health. Action taken now will ensure that we are seen by China and India as a partner with much to offer. An enhanced science and technology relationship, appropriately managed, will generate new opportunities of mutual benefit to cooperating countries. It will also make Australia more visible to these emerging economic superpowers.

We need to ensure that Australian business is provided with the best possible environment in which to prosper, grow and compete. It is important to Australia's international competitiveness that the environment in which Australian businesses operate is conducive to investment in R&D, growth and exporting. The Government's policies have provided a stable economic environment with good economic growth over an extended period. Deregulation of the labour market will further enhance our competitiveness. The Government has recognised the benefits that flow to the wider economy from business investment in R&D. It provides assistance for business R&D, and for research cooperation between universities, government laboratories and the private sector. The Government has also put in place programmes to encourage venture capital investment.

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[28] The Hon. John Howard MP; *Address To The Business Luncheon*, loc. cit.

However, Australia's business expenditure on R&D (BERD) is low, 0.89 per cent in 2003, ranking us eighteenth in the OECD. If very small countries such as Finland (2.45% BERD - 2003) and Denmark (1.83% BERD - 2003) can achieve high levels of business expenditure on R&D and expansion in overseas markets with resulting positive trade balances, then Australia should be able to do likewise.[29] While Australia currently lacks some of the high R&D intensive sectors that contribute to the high BERD rates elsewhere, we need to make up for this with a strong R&D performance in sectors in which we have or wish to create real competitive advantage.

Measures to encourage business R&D

In order to be competitive in this twenty first century environment, Australian industry will need to leverage global resources to compete successfully in global markets. In a report published in April 2006, the Australian Industry Group argued for a series of measures, including changes to tax treatment of R&D and rules regarding intellectual property, to make it much easier for Australian industry to collaborate with global R&D partners.[30]

R&D tax concessions are used extensively by OECD countries as an indirect way of encouraging business investment in R&D. A range of new tax incentive measures has been introduced in recent years. In addition, a number of countries have made changes to existing schemes to make them more generous. While some incentives reward incremental increases in R&D, there has been a trend to providing support based on expenditure in a given year.

The OECD reports that nine OECD countries provide R&D tax credits based on the level of R&D and six countries on the basis of incremental increases in R&D. In addition, six countries provide tax concessions for R&D.[31]

Some ten OECD countries provide additional tax incentives for R&D conducted by small and medium sized firms. Non-OECD countries, such as Singapore and Malaysia also provide tax incentives for R&D.

To ensure our service and manufacturing sectors are positioned in the highest quality niche areas of innovation and design in areas such as medical and bioscience, animal health and engineering design, we need to encourage strong linkages between universities, research institutions and our business sector.

In order to be competitive as an economy, and to have the science and business capabilities to make us an attractive partner to China and India, Australia needs to strengthen its science, education and business base. Not to do this will result in our being marginalised by the emergence of these new economic superpowers. Australia needs to identify areas where it can successfully compete and put in place structures to grow both our domestic business and our global market share. We need to establish partnerships and joint ventures with overseas R&D providers. We also need to increase our understanding of these complex cultures and context-rich countries.

Australia faces challenges and opportunities in the new global economy. We need to take steps now to ensure the future competitiveness of our education, research and business base.

[29] OECD, *Main Science and Technology Indicators Database 2005/2*; OECD Publishing; 2005

[30] Australian Industry Group, *Manufacturing Future: Achieving global fitness*; The Australian Industry Group; April 2006; pp. 63 - 64

[31] *OECD Science, Technology and Industry (STI) Outlook 2004*; Paris: OECD; 2004; pp. 66-68. (Note: A tax credit is an amount deducted directly from income tax otherwise payable and may be carried forward or back, or cashed out. A tax concession is an amount deducted from total income to arrive at taxable income. If the concession exceeds the amount of taxable income, then part of the benefit is lost. Tax concessions are not portable across financial years).

Innovation as a response to globalisation

> "Australian manufacturers can compete in the global marketplace, not by reducing cost, but by adding value through innovation. Innovation which delights the customer will enable global competitiveness. Academics need to be involved with industry, industry need to support engineering education. Collaboration between industry, researchers and academia can provide the intellectual value for Australian success."
>
> *Dr Laurie Spark, Chief Engineer, Holden Innovation, and Adjunct Professor at RMIT*

Australian industry is dominated by small to medium sized enterprises, with relatively low R&D intensities. It is difficult for these businesses to gain traction in export markets, but because of the small size of the Australian market, many of them must export in order to grow.

At 0.33 per cent of GDP, Australia's expenditure by government research agencies on R&D ranked eighth among OECD countries in 2002, compared to the OECD average of 0.28 per cent. By contrast, at 0.89 per cent, Australian business expenditure on R&D as a proportion of GDP in 2002 was well below the OECD average of 1.53 per cent, ranking Australia eighteenth amongst OECD countries.[32]

It is sometimes argued that Australia does not need to perform its business R&D at the same level as other OECD countries because we are good at adopting technology from elsewhere. However, in order to be successful at using technology from other countries we need to adapt it to our needs and this requires a strong business R&D base in Australia.

The structure of Australian industry goes some way to explaining our poor business R&D performance. However, a recent OECD report showed that Australia still ranked very poorly on this indicator even when allowance was made for structure.[33] Professor Tom Spurling, President of the Federation of Australian Scientific and Technological Societies points out that "capturing the value of public sector research is greatly enhanced when there are companies that themselves have an R&D capability and an active programme of turning research into new products and processes."[34]

Governments recognise the importance of links between public research organisations and industry. The concept of 'Third Stream' funding is already in place in the UK and is under consideration for Australia.[35] Existing Government programmes aimed at building stronger linkages include the ARC Linkage Schemes, Cooperative Research Centres, COMET and Pre-seed Fund programmes. It involves expanding the traditional mission of universities (teaching and research) to include engagement with business and the community.[36] In the UK, the Lambert Review of Business-University Collaboration recommended a strengthening of existing schemes for the transfer of knowledge between sectors and highlighted the need for links to be two-way.[37]

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[32] OECD, *Main Science and Technology Indicators*; loc. cit.
[33] OECD, *Economic Policy Reforms: Going for Growth 2006*; Paris: OECD; 2006
[34] Professor Tom Spurling, *R&D, where a little buys a lot*; Australian Financial Review; 27 March 2006; sec. Education; p. 33
[35] 'Third stream' is a policy, programme and funding focus on the various ways in which universities engage with business and the broader community to deliver economic, social and environmental benefits.
[36] Federation of Australian Scientific and Technological Societies, *The structure of a prospective Australian Third Stream Fund* [on-line]; available from http://www.fasts.org/Fsite/Forums/Forum.htm; Internet; accessed on 11 April 2006
[37] HM Treasury, *Lambert Review of Business-University Collaboration, Final Report*, Her Majesty's Stationery Office; December 2003

"The main challenge … is not about how to increase the supply of commercial ideas from the universities into business. Instead, the question is about how to raise the overall level of demand by business for research from all sources."[38] Excellent science does not automatically result in innovation. We tend to use science and innovation in the same breath, but they are not interchangeable. The engineering process and subsequent development of the technology is actually the start of the commercialisation process.

> "Australia has many great publicly funded research agencies doing excellent basic research. However, there is often a rush to publish and insufficient strategic collaboration with the private sector, resulting in lost opportunities for commercialising the intellectual property. The only ultimate measure of success of publicly funded industrial research is the creation of strong IP that earns income"
>
> Bruce Grey, Chairman Advanced Manufacturing Action Agenda

The working group has observed that there is a real need to simplify the transfer of intellectual property from the public sector to industry. Australia's universities and public sector research organisations have different arrangements for managing and commercialising their intellectual property. Further, these public sector organisations lack clear incentives to get their research outcomes into the marketplace.

Australian universities have commercialisation offices or companies. Commercialisation of IP has until recently been seen as a secondary priority compared with the core teaching and research missions. While some universities have been in a position to provide their commercialisation arms with the necessary resources to facilitate successful commercialisation of IP, the research budgets of many universities are too small to justify the investment.[39]

A recent report jointly commissioned by the AVCC and the Business Council of Australia signalled the need for a clearer national policy or framework on the ownership and management of IP policies in publicly funded research institutions, particularly universities (Allen Consulting Group, 2004). It identified three issues that are causing concern: 1. Australia does not have experimental use exception provisions. 2. Universities must also comply with State requirements, including approval from universal governing bodies for all commercial activities. 3. Some universities are constrained by their requirement to seek approval from the relevant State education ministers. These issues produce time delays, administrative burdens and concerns from commercial partners about confidentiality, which are perceived to inhibit the commercialisation of IP.[40]

To improve Australian business innovation, the working group recommends that the Government facilitate Australian private sector investment in R&D by supporting public-private R&D partnerships especially in the priority areas of energy, water, agriculture and health (for additional information about the process for identifying these priority areas see Appendix 7). The working group suggests that this become another element of funding and evaluation of public sector research organisations.

[38] HM Treasury; *Lambert Review of Business-University Collaboration, Final Report*; December 2003; p. 3

[39] *Draft OECD Thematic Review of Tertiary Education: Country Background Report Australia,* DEST, Canberra; 2006

[40] ibid.

Industry must internationalise in order to compete

Globalisation is having profound impacts not only on Australian industry but across industry in all developed countries. Increased global competition, the rapid uptake of new technologies, emergence of global supply chains, the thirst to be lean in containing costs, and the search for the next emerging market are changing the way companies operate.

Australia's innovation is open to the competitive positioning of the rest of the world. Currently we are a good integrator of technology, as are countries like Ireland, Singapore and the Netherlands. But at the same time, Australia can also develop first to market technologies in some areas and in other areas we will buy in best of world technologies. In that respect, what Australia needs to do consistently well is to be a very smart integrator of domestically generated and internationally acquired technologies.

The impact of globalisation can be seen in the emergence of the new players, China and India. Today, emerging economies account for almost half of the world's GDP. During the nineteenth century industrial revolutions of the US and UK it took 50 years to double real incomes per head; China is achieving this in a single decade.[41]

For Australian business, whether it be a small family enterprise, a listed Australian company or an affiliate of an overseas entity, the way business conducts its research and development, and innovation more broadly, can be expected to change due to the impact of globalisation.

Business expenditure on R&D in Australia is currently over $7.22 billion.[42] While around 38,000 full-time equivalent people are engaged in R&D activities, only 5,100 businesses in Australia (or 0.17 per cent) undertake R&D in any one year. Manufacturing and services each account for about 45 per cent of these activities. The high concentration of our business R&D in manufacturing, where the competitiveness of our domestic production is rapidly eroding, means that Australia's business, science and innovation efforts are highly exposed to the forces of globalisation and change.

This is particularly so given the importance of foreign corporations to Australia's industrial landscape. There are around 2,300 affiliates of over 680 overseas-owned corporations based in Australia. Many are affiliates of US corporations, with one third of the top 200 foreign owned companies being US owned. While they constitute less than 0.3 per cent of all Australian business, they account for over 40 per cent of business expenditure on research and development.[43] This is a clear example of Australia benefiting from the globalisation of R&D. However this could also be construed as a threat, should these overseas corporations decide to relocate their R&D efforts.

The strong presence of multinational corporations is also acting to draw Australian-owned companies more rapidly into integrated regional and global production strategies. With the application of global competitive strategies, comes the need for cost reductions, greater use of global supply chains, pressure to source low cost imports, and movement of production closer to overseas markets. These developments have heightened competition and accelerated the need for change. But they also offer opportunities if Australia can find a sustainable space in selected markets and technologies to compete successfully in the global marketplace.

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[41] The Economist Newspaper and The Economist Group, The Economist, 21 January 2006; p. 12

[42] Australian Bureau of Statistics, *8104.0 - Research and Experimental Development, Businesses, Australia, 2003-04* [on-line]; available from http://www.census.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8104.0Media%20Release12003-04?opendocument&tabname=Summary&prodno=8104.0&issue=2003-04&num=&view=; Internet; accessed on 11 April 2006

[43] Commonwealth of Australia, *Mapping Australian Science and Innovation;* The Science and Innovation Mapping Taskforce; Department of Education, Science and Training, Department of Industry, Tourism and Resources, Department of Communications, Information Technology and the Arts; 2003; Australian Bureau of Statistics, 2004, *Foreign Ownership of Australian Exporters and Importers*.

As in other developed economies, Australian industry is going through a significant period of restructuring in response to the emergence of China, and to a lesser extent, India.[44] This process of restructuring is occurring at a time when Australian manufacturing is also experiencing a cyclical downturn in response to softer household spending, a weak housing market, weak domestic automotive manufacturing sector and a relatively high Australian dollar, making exports less competitive. Indeed, in terms of manufactured exports, the emergence of China has seen Australia's share of world exports drop from 1.2 per cent to 1.0 per cent, or 18 per cent, almost three times the rate of loss suffered on average by OECD countries overall.[45]

So how is industry responding, and what are the implications for Australia's science and innovation effort? The report by the Australian Industry Group, *Manufacturing futures: Achieving Global Fitness*, provides a useful overview of strategies being introduced by Australian businesses.[46] These strategies include:

- Taking advantage of the cost competitiveness of the emerging economies by outsourcing segments of activity to these centres
- Positioning themselves to take advantage of surging purchasing power in the rapidly growing economies
- Investing around the globe in new ventures.

Australian manufacturers are also creating new capabilities to apply both domestically and as part of their global engagement. Manufacturers are:

- Investing in skill creation and supplementation
- Automating production
- Investing in research and development
- Sourcing knowledge from overseas
- Developing new products, services and processes
- Renovating business operations - both internally and throughout their supply chains.[47]

Intellectual property rights

An issue for businesses and researchers in their dealings with China and India is protection of intellectual property rights (IPR). Appendix 6 provides an analysis by IP Australia of IPR in those countries and likely trends. China and India are making substantial progress toward the development of systems that comply with their WTO obligations. However, both countries still have work to do to ensure accessible, transparent and efficient regimes that deter infringement, provide for redress where infringement occurs and inform community attitudes. The Australian Government could influence the development of IPR systems in China and India that have these attributes by: working through the WTO and WIPO to ensure compliance; negotiating commitment to IP regimes in free trade discussions; building capacity through training of administrators and judiciary; promoting bilateral relationships between IP offices; and equipping Australian business with the tools to work more effectively with the IPR systems in those countries.

[44] KPMG International, *Industrial and Automotive Products - Globalization and manufacturing*; The Economist Intelligence Unit Limited; February 2006

[45] The Australian Industry Group, *Balancing the Risks: Building Australia's Economic Resilience*; The Australian Industry Group; December 2005; p. 13

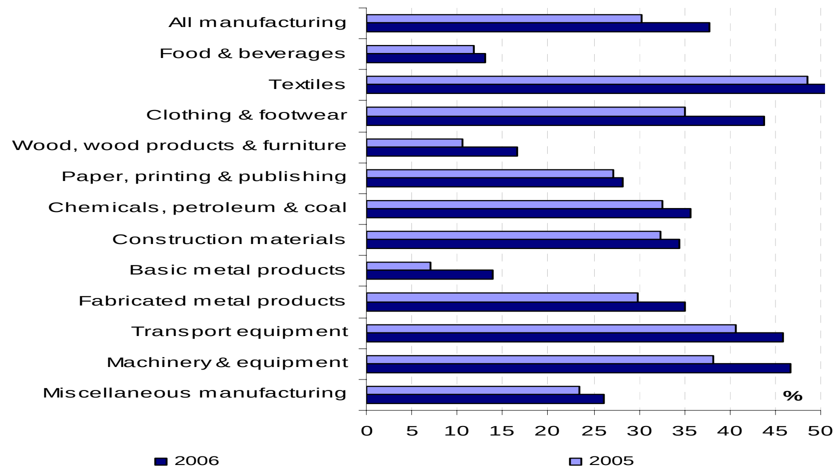
[46] The Australian Industry Group, *Manufacturing Futures*; loc. cit.

[47] The Australian Industry Group, *Manufacturing Futures*; loc. cit.

Two trends are particularly significant for the future development of Australia's business science and innovation efforts – collaboration and new product development. Leveraging global production capability is becoming a major business strategy for globally competitive businesses. This takes two forms: companies moving part or all of their operations overseas; and/or using a greater share of imported materials/components in domestic production. Both are seen as a major means of achieving cost reductions, although overseas production is equally motivated by the need to be close to emerging markets.

Increasingly, Australian companies will be looking to tap into global supply chains and new markets to secure these benefits. In manufacturing, about 30 per cent of current sales are derived from foreign inputs (components and raw materials), and this is expected to rise to 38 per cent over 2006.[48] Overseas inputs to Australian firms are illustrated in Figure 3 below.

Figure 3: Overseas inputs as a percentage of sales



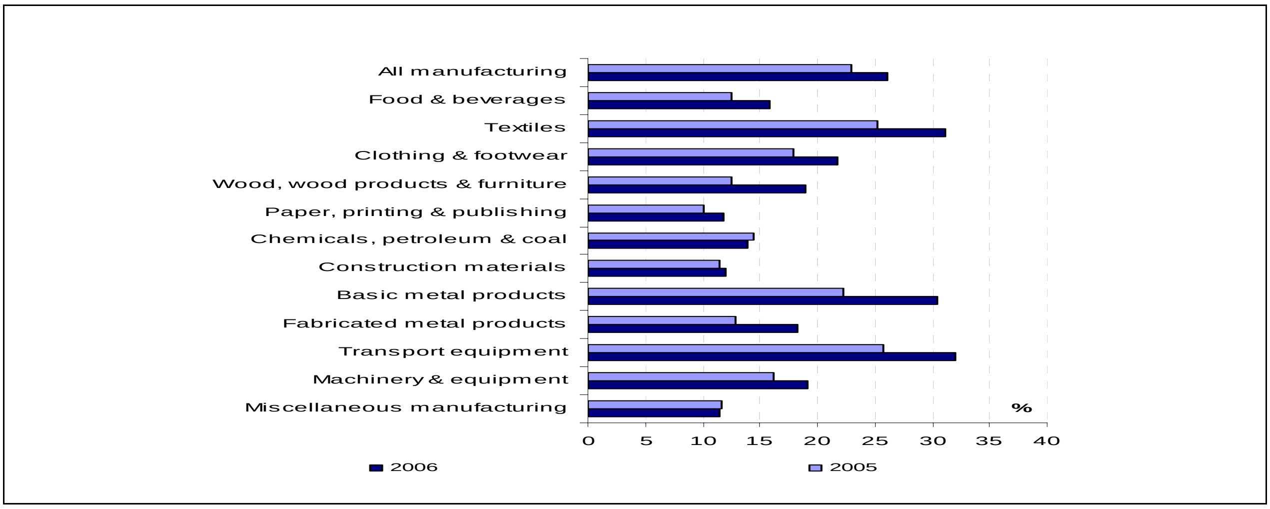
Source: Australian Industry Group, *Business Prospects for Australian Manufacturing in 2006*, February 2006

There are encouraging trends that, in spite of the erosion of Australian manufacturing, businesses are becoming more innovative. Faced with intense price pressure from low cost countries, many businesses are looking to develop new products and services and to protect these through the preservation of intellectual property rights.

This trend towards using innovation as a competitive strategy in Australian manufacturing is seen through the increasing proportion of sales being derived from new products, particularly in the automotive and components, and textiles sectors, where global competition is most intensive. Currently 23 per cent of manufacturing sales are derived from new products and services, developed over the last three years, and this is expected to rise to 26 per cent by the end of the year (see Figure 4 below).

[48] Australian Industry Group, op. cit., p. 6

Figure 4: New products as a percentage of sales



Source: Australian Industry Group, *Business Prospects for Australian Manufacturing in 2006*, February 2006

There are opportunities for Australian business R&D to grow with the development of global arrangements, but this requires the domestic marketplace to deliver appropriate training, skills, tax incentives and a business environment conducive to business growth.

As production and sourcing moves offshore, inevitably it will mean that some research and development currently undertaken in Australia will move offshore with it. Both China and India are developing competitive and highly credentialed R&D facilities and a ready supply of scientists and engineers to facilitate this technology development. Many expatriate, high calibre Chinese researchers are being lured back to China from the US and elsewhere to conduct their research in world class, well resourced institutes and laboratories built specifically for the purpose.

The case of BHP Billiton (see media release on page 20) is illustrative of how Australian companies will develop R&D partnerships in overseas markets in line with the growth of overseas markets and business partners.

The question for the Australian Government is how to support companies operating in Australia in their efforts to take advantage of the research and innovation opportunities from global engagement, and yet continue to grow Australia's existing domestic R&D efforts. Therefore, we need to support domestic R&D and encourage increasing global collaboration.

To capitalise on the opportunities arising from the rapid growth of India and China, Australia needs to build a stronger business research base, improve our environment for innovation and encourage R&D that addresses the highest priority needs of China and India in areas where we have global strength.

Recommendation 1

Australia needs to capture the opportunities created by the emergence of China and India by encouraging business engagement in our four priority areas, stimulating business investment in R&D, and simplifying private company access to publicly funded intellectual property.

Based on the working group's extensive consultations we believe that the greatest opportunity for sustainable growth lies in focusing on those areas of priority need for China and India where we have world class capability - energy, water, agriculture and health (for additional information about the process for identifying these priority areas see Appendix 7). Many of the companies that provide products and services in these areas are SMEs. Encouragement will need to be provided to support and facilitate business engagement with these countries. This can be partially accomplished by focusing some of Austrade's activities on the priority areas mentioned above.

Strengthening private sector investment in R&D is essential to strengthening Australia's knowledge capability. This could be accomplished by implementing new initiatives to encourage public-private R&D partnerships and reviewing relevant tax and other fiscal incentives to ensure that the net benefits to Australian companies are competitive with those of OECD countries.

The working group identified through its consultation process that Australia faces a key issue in commercialising intellectual property arising from public investment. In order to fully leverage the investment, and maximise economic benefit, the process through which private companies can access publicly funded intellectual property must be simplified and encouraged.

CHAPTER 3 ENHANCE LINKS WITH CHINA AND INDIA

This Chapter discusses the importance of science, technology and education linkages, benefits to Australia from such linkages and the limited existing Australian S&T collaboration with China and India. Factors driving industry collaboration, and emerging trends in this area are also discussed.

Building our knowledge base

With the rising importance of China and India, it is essential that Australia's approach to these two countries undergoes a significant change. Our past efforts have been characterised by a lack of serious allocation of funds and limited follow up and have been dominated by an aid mentality. The working group believes that Australia must send a message that it is serious about its relationships with these two countries. The proposal to establish two major science and technology cooperation funds (Recommendation 3) will go a long way to meet this objective, as well as provide visible and tangible benefits for Australia.

In order to do this, Australia must have a consistent and transparent whole-of-Government strategy that drives collaboration so that all activities and interactions with China and India are coordinated and effective. This strategy should take account of the needs of China and India, as well as Australia's strengths and areas in which we want to develop capacity. For China, energy, biomedicine, agriculture, mining equipment and safety, and water technology are areas of common interest.[49] For India, nanotechnology, biotechnology, sustainable energy, astronomy and astrophysics, material for microelectronics and semiconductor devices, and tsunamis are areas of common interest. Concentrating Australian cooperation in these areas will ensure visibility and impact.[50]

After analysing India and China's priority needs, and Australia's strengths and emerging niche capabilities, the working group recommends strong focus in four priority areas of - energy, water, agriculture and health and development of linkages in biotechnology, medical devices, engineering design and animal health (for additional information about the process for identifying these priority areas see Appendix 7).

There are a number of reasons why Australia should enhance its S&T cooperation with China and India. Because Australia invents only a very small fraction of our technological requirements, we are very dependent on the rest of the world for the technology that underpins the success of our economy and our living standards. International S&T collaboration is essential to keeping Australia's scientists and engineers in touch with new developments in their fields of research.

China and India are also important locations for business and industry collaboration and partnerships. As noted in the previous chapter, such partnerships can help build the competitiveness of Australian firms and create new markets for their products and services. Knowledge generation and use is now a global business. Australian researchers and businesses need to be encouraged to develop strategic overseas R&D partnerships. At the same time, Australia should provide an environment that encourages foreign firms to undertake R&D in Australia.

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[49] Professor Xu Guanhua, Chinese Minister for Science and Technology; address to Fellows; Australian Academy of Science; 16 February 2006

[50] Minutes of Joint Science and Technology Commission meeting; Canberra; 29 July 2005

The aim is to build Australia's knowledge base in order to compete successfully in the global marketplace.

China and India, with their large populations, can provide significant high-quality collaboration opportunities. Australian researchers can bring their experience from these collaborations back to Australia. University researchers pass new ideas and skills to students, and through this mechanism, into the Australian economy, creating jobs, products and services.

Existing Government programmes

Creating scientific exchanges between countries has been an important first step in the creation of lasting diplomatic relationships.

Appendix 2 provides an outline of Commonwealth Government programmes for international science collaboration with China and India. At present, Australian S&T cooperation with China and India is supported through a number of channels, but primarily through the Australian Research Council Linkage projects and the Department of Education, Science and Training International Science Linkage programme, and whatever internal resources our research groups such as CSIRO and universities devote to international work. In 2005 ARC Linkage provided an estimated $7.3 million for collaborative projects with China and $14.1 million with India; and the DEST International Science Linkage programme provided an estimated $457,000 for collaborative projects with China and almost nothing with India. These programmes have had very small allocations of funds and are investigator-driven. Much of the available funding is used to support valuable collaboration projects with the US.

From 2007 the Australian and Chinese Governments will quadruple the size of the Australia-China Fund for Scientific and Technological Cooperation to $4 million.[51] The Fund is part of the International Science Linkages programme of *Backing Australia's Ability*, and supports collaboration between Australian and Chinese researchers in agreed areas of priority.

During his visit to India in March this year, Prime Minister Howard announced a new bilateral research programme with India valued at $25 million over five years. The package includes: $20 million for establishment of an *Australia-India Strategic Research Fund* to promote multi-disciplinary collaboration between Australian and Indian researchers; $3.5 million for *Endeavour India Research Fellowships* for top researchers from both countries to undertake short term postgraduate and postdoctoral research in any field of study; and $1.5 million for an *Endeavour Executive Awards* programme for professional development of high achievers in business, industry and government from both countries at counterpart organisations.

This is a very good start, but it needs to go further. In particular, we need something similar for China, such as a programme of fifty annual post-doctoral fellowships for Chinese students to work in science and engineering fields in Australia, including universities, CSIRO and other Government research agencies. These postings are likely to result in personal linkages that could be important foundations for international R&D collaborations.

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[51] The Hon. Julie Bishop MP, *Scientific cooperation to grow between Australia and China* [on-line]; available from http://www.dest.gov.au/Ministers/Media/Bishop/2006/04/b001240406.asp; Internet; accessed on 24 April 2006

The Government also announced in April 2006 a doubling of funding for scholarships to students and researchers from the Asia-Pacific, under the Australian Development Scholarships and Australian Leadership Awards programmes administered by AusAID and the Endeavour Scholarships programme administered by the DEST. A total of $1.4 billion will be provided for 19,000 scholarships over a five year period.[52]

Other countries' links with China and India

Australia has had low level S&T cooperation with China and India for many years. As a result, our S&T visibility in these countries is also low. Other OECD countries have developed mechanisms which provide a greater degree of visibility and focus. These mechanisms fund major projects and joint research centres focused on areas such as nanotechnology (see Appendix 4). In addition, the presence of major business research centres (eg Microsoft), particularly in India, has helped the relevant governments to build other S&T links.

Other OECD countries not only provide significantly higher levels of support for international S&T activities, but have also identified a need to provide dedicated funding for collaboration with India and China.

There is a need for dedicated investment by government in S&T collaboration with China and India. Grant schemes such as those run by the ARC and the NHMRC, allocation from CSIRO, and support schemes such as the R&D tax concession and other R&D programmes, should be revised to encourage greater international involvement (in both directions), subject to appropriate safeguards.

The United Kingdom provides a useful example of a government partnership with China. On 20 December 2005, the Chief Scientist of the UK, Sir David King, personally completed negotiations on a series of important science projects with China on crucial topics, such as clean coal and GRID computer technology. Included are: a £3.5 million project on clean coal research over a three-year period, and Avian Flu research programme and the recently launched China Open Middleware Infrastructure Institute in Beijing at the Chinese Academy of Sciences Computer Network Information Centre. In education, the recently established University of Nottingham-Ningbo is the first official Sino-foreign joint venture university in China.

These initiatives, and similar successes by Canada and France (see Appendix 4), are the result of carefully orchestrated, sustained campaigns involving senior government and science leaders, and heads of research institutes all working towards a common goal.

Areas for collaboration

The allocation of significant funding to collaborative research by some OECD countries has also helped to engage the attention of the Chinese and Indian Governments. High profile visits by leading scientists, including the Chief Scientist, should also be part of Australia's strategy to engage with India and China. The visit by Sir Gustav Nossal to India in 2005 has had a major impact on Australia's S&T relations with that country. Australia can learn from the experience of other countries. The visits by Australian Deans of Engineering to India, and the consortium established as a consequence, is a mechanism for marshalling critical mass from Australia.

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[52] The Hon. Julie Bishop MP and The Hon. Alexander Downer MP, *Australia doubles the number of scholarships to the Asia-Pacific region* [on-line]; available from http://www.dest.gov.au/Ministers/Media/Bishop/2006/04/B002260406.asp; Internet; accessed on 26 April 2006

Research collaboration with other countries needs to aim at achieving mutual benefits to the participating countries. As a consequence, the priorities of collaborating countries need to be taken into account when investing in major new projects. Australia's S&T priorities have been defined by the Government.[53] The priorities of China and India are also documented. During his recent visit, China's Science Minister, Professor Xu, identified China's priorities for collaboration with Australia as:

- Energy (particularly clean coal, energy efficiency technologies and next generation fuel cells)
- Biomedicine (with opportunities to develop products derived from China's traditional medicines, and stem cell research)
- Agriculture (including animal husbandry)
- Mining equipment and mine safety (where Australia is considered to be very innovative)
- Rare earth technologies (which have a variety of industrial and agricultural applications)
- Water (quality, accessibility and sustainability).

Governments have an important role to play in encouraging S&T and business links with China and India. In the absence of government encouragement, investment in collaboration with these two countries is clearly much less than is desirable, given the future size, purchasing power and political importance of these two economies. Both China and India place considerable importance on government-to-government agreements and investment in collaboration, such as through joint research, exchange of personnel and symposia in areas of emerging interest.

We need to urgently upgrade Australia's science and innovation capacity through our interactions and collaborations with India and China as their capabilities expand rapidly over the next decade. The creation of new, dedicated bilateral funds to support this activity is essential, in order to focus attention on, and to achieve, such collaborations.

Multidisciplinary centres of excellence, innovation precincts or joint institutes, which draw on Australian expertise supported by bilateral government funding, would showcase our capabilities and provide us with new R&D opportunities. Such collaborations would build Australia's profile in-country and have flow-on benefits into other disciplines for collaboration between Australian, Chinese and Indian researchers.

[53] Australian Government, Department of Education, Science and Training, *National Research Priorities* [on-line]; available from http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/national_research_priorities/default.htm; Internet; accessed on 10 April 2006

Media release

First Indo-Australian research institution

Monash University and the Indian Institute of Technology Bombay have created the first joint institution for research and research training in areas of mutual importance to India and Australia.

The Indo-Monash Research Academy will be a centre of excellence in research and clean energy, water, biotechnology, minerals exploration and computer simulation.

The independent research academy will be located in a state of the art facility on the Powaii campus of IITB. A separate governing board will oversee the activities of the academy. The academy will enable both the IITB and Monash University to interact with Indian, Australian and global corporations to accelerate the translation and commercialisation of world class research.

The Academy will undertake fundamental research, graduate training and industry engagement. "This initiative brings together two world class institutions for training the next generation of scientists and engineers contributing to the future economic growth of both countries," said Professor Richard Larkins, Vice-Chancellor of Monash University.

Professor Ashok Misra, Director of IITB, welcomed the development. "The chance to create globally competitive teams of researchers addressing problems of relevance to the global industry and community is an exciting opportunity," he said.

BHP Billiton, the world's largest diversified resources company, is supporting this initiative with a commitment to joint research and commercialisation. "This agreement means that India's finest scientific minds will be working with BHP Billiton to jointly develop and commercialise leading edge technology and extend the global reach of our innovation," said Dr Megan Clark, Vice President of Technology, BHP Billiton.

People-to-people links

In addition, Australia should increase the opportunities provided to high quality students from India and China. Experience with the Colombo Plan shows that, by providing training in science and engineering, Australia can create a new generation of graduates in those countries with strong links to Australia.[54] These links, if exploited actively, can create future business opportunities for Australia and build goodwill with potential future leaders in business, government and academia.

[54] The Colombo Plan for Cooperative Economic Development in South and South-East Asia (the Colombo Plan) was inaugurated at a meeting of Commonwealth Foreign Minister's in Colombo, Ceylon, in 1950. The Colombo Plan began with two separate arms, one being economic development inviting financial support for developmental projects such as dam and road-building, and another being technical assistance, the promotion of technical expertise, education and training in a broad range of activities that logically assisted economic development and sound administration.

Currently, Australia does not attract the top echelon of Indian or Chinese students. Market intelligence in China and India suggests that Australia is only the third preferred destination for students from those countries studying abroad. The best go to the US or the United Kingdom. New programmes to attract high quality students from these countries, together with a reduction of the pressure on universities to meet budgets by chasing quantity rather than quality fee paying foreign students, are therefore critical. Further, we should generate high quality research projects in those areas of common interest. We must also make it easier for these students to stay on in Australia for further study and research or possible employment.

To meet the challenge and opportunities provided by the rapid development of science and technology in India and China, Australia needs to dedicate a significant investment to promote and strengthen links in education, science, technology and technology-related business and build on recently announced initiatives.

Recommendation 2

Australia needs to enhance the linkages with China and India by developing a whole of government strategy for engagement and by investing in collaborative knowledge infrastructure.

The development of a whole-of-government strategy for engagement with China and India in science, technology and engineering needs to be transparent, based on mutual benefit, consistent across government and built upon our strengths. This should include providing strong government leadership in building science, technology and engineering links with China and India.

The investment in collaborative knowledge infrastructure, including people and facilities, should be jointly funded and focus on key areas of energy, water, agriculture and health and also extending to niche areas, such as medical and bioscience, animal health and engineering design. Such infrastructure should include joint international centres of excellence, joint symposia on the above areas, and support for collaborative R&D projects.

CHAPTER 4 STRENGTHEN THE FOUNDATIONS FOR COMPETITIVENESS

This chapter reviews factors which impact on Australia's research and industrial competitiveness and identifies issues that need to be addressed if we are to be a competitive economy in the twenty first century.

Knowledge must become Australia's top priority

> "Every advanced industrial country knows that falling behind in science and mathematics means falling behind in commerce and prosperity"
>
> The Rt Hon. Gordon Brown MP, Chancellor of the Exchequer, Budget Speech March 2006

Knowledge is recognised as the key factor in economic and social advance in most OECD and many other countries including China and India.

> "America's economic strength and global leadership depend on continued technological advances. Ground breaking ideas generated by innovative minds have paid enormous dividends improving the lives and livelihoods of generations of Americans" (President Bush, US State of the Union address, January 2006).

The Australian Government has increased funding for science and technology through *Backing Australia's Ability* initiatives (2001 and 2004) and *Backing Australia's Future* (2004) (see Appendix 3). However, we have not taken the necessary steps to build on the inventiveness of our scientists, engineers and business people. In spite of the Government's initiatives, there are still shortages of funding for research, short term contracts for junior scientists with no career security, relatively few elite students choosing to study science at university and relatively low entry level requirements.

Other countries are putting in the effort at government level (see Appendix 4). This includes the increasing national priorities for science, technology and engineering, levels of investment support and support for the development of international collaborations.

Globally we compete successfully in sport because we invest in sport. Our current levels of investment in S&T are not sufficient to ensure that we are competitive in the twenty first century. We need to increase our investments in education, high quality S&T and building relationships with countries such as China and India.

Australia's international S&T effort is small even taking into account our size.[55] This leads to problems when we try to build relations with other countries. As one recent visitor to India reported:

> "Australia isn't taken seriously by India's scientific establishment. Nothing happens after delegations and MOUs; there is no follow-up. What is missing is long-term policy. India's interest in education in Australia is only linked to immigration. And we are seen as trying to sell bottom-end education".[56]

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[55] The Allen Consulting Group, *A Study of International Science and Technology Policy and Programs*; Commonwealth of Australia; Department of Education, Science and Training; 2003

[56] John Grace, *Australia / India Collaboration in Research and Innovation*; CEO, Nextec Biosciences P/L; presentation to the working group; 18 August 2005

The scale of the emerging S&T effort in China and India is impressive, as is the response from the US and Europe. If we are to remain relevant, Australia needs a major response, led by the Australian Government, to strengthen our domestic knowledge base, to facilitate companies and research groups to internationalise while retaining a strong local presence. We need to build large scale international collaborations, particularly with China and India.

Australia needs a critical capacity in science, engineering, technology and innovation to create, recognize and capture global opportunities.

Competitiveness is built on a strong education system

China and India

Education is the gateway to opportunity and the foundation of a knowledge based innovation-driven economy. Both China and India are investing heavily in higher education to achieve their development objectives.

In China the number of higher education graduates grew 288 per cent between 1997 and 2004.[57] The number of doctoral degrees awarded grew 286 per cent between 1995 and 2001, while doctoral degrees in science and engineering grew 239 per cent over the same period.[58] In 2003 science and engineering accounted for 57 per cent of all first university degrees awarded in China (compared to 28 per cent in Australia), 66 per cent of which were in engineering (compared to 30 per cent in Australia).[59] In 2001 science and engineering accounted for 65 per cent of doctoral degrees earned in China (compared to 55 per cent in Australia), 53 per cent of which were in engineering (compared to 21 per cent in Australia).[60]

India has also experienced rapid growth in its investment in higher education. The number of universities rose from 209 in 1990 to more than 300 in 2005.[61] Over a similar period, enrolment in higher education institutions rose from 4.9 million (in 1990-91)[62] to 9.9 million (in 2004)[63] and science degree holders rose 60 per cent and the number of science postgraduates rose 50 per cent (see Figure 1.13 Appendix 1). In 2002 science and engineering accounted for 46 per cent of doctoral degrees earned in India, 13 per cent of which were in engineering.[64] In 2004 India produced an estimated 215,000 engineering graduates.[65]

[57] Ministry of Science and Technology of the People's Republic of China*, S&T Statistics Data Book*; loc. cit.
[58] US National Science Foundation, *Science and Engineering Indicators 2006* [on-line]; available from http://www.nsf.gov/statistics/seind06/pdfstart.htm; Internet; accessed on 11 April 2006; Table 2-43
[59] ibid.; Table 2-37
[60] ibid.; Table 2-40
[61] *UNESCO Science Report 2005*; loc. cit.
[62] Planning Commission, Government of India, *Tenth Five Year Plan*
[63] Department of Elementary Education and Literacy, and Department of Secondary and Higher Education, Ministry of Human Resource Development, Government of India, *Annual Report 2004-05*
[64] ibid.; Table 2-40
[65] NASSCOM, *Strategic Review 2005*; loc. cit.

United States

In his State of the Union Address to the US Congress in January 2005, President Bush announced $380 million in new federal support to improve the quality of science, mathematics and technology education in secondary schools and to engage every child in rigorous courses that teach analytical, technical and problem-solving skills.[66] This announcement followed publication of a number of alarming reports published in the US by the National Academies and the National Science Foundation.

In its report to the US Senate Committee on Energy and Natural Resources in 2005, the National Academies Committee on Science, Engineering and Public Policy observed that “the critical lack of technically trained people in the United States can be traced directly to poor K-12 mathematics and science instruction. Few factors are more important than this if the United States is to compete successfully in the twenty first century.”[67] In a proposed ‘best and brightest’ scheme, talented young students would receive incentives to enter the S&T workforce through competitive undergraduate scholarships in science, mathematics and engineering. Automatic one year extensions of visas would be granted to foreign university graduates in these disciplines, with expedited residence status upon employment.

In presenting the Committee’s report to Congress in October 2005, Chairman Norman Augustine, pointed out that “human capital - the quality of our work force - is a particularly important factor in our competitiveness…Our public school system comprises the foundation of this asset. But as it exists today, that system compares, in the aggregate, abysmally with those of other developed - and even developing - nations…particularly in the fields which underpin most innovation: science, mathematics and technology.”[68]

In January 2006 the US National Science Board was so concerned about the condition of science, technology, engineering and mathematics (STEM) education, that it published a companion policy statement to its biennial report on science and engineering indicators. The statement expressed concern that the US “continues to slip behind in the science and mathematics achievements of US students relative to international peers...The intractability of this widely recognized systemic failure is alarming…We cannot wait for a new Sputnik episode to energize our population to rise to the challenge.”[69] The statement identified priorities for building a new foundation for a world class education in STEM fields, namely:

- Strong public support for the value of STEM education for all students and citizens
- A high quality teaching workforce
- Appropriate opportunities to learn for all students
- Effective guidance counselling on STEM education and careers
- Assessment tools that reinforce learning in STEM fields.

The statement identified lack of suitably qualified teachers, poor remuneration compared to other STEM professionals and lack of ongoing professional development as factors affecting student achievement in STEM subjects and their preparation for working life.[70]

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[66] The White House, *American Competitiveness Initiative*; loc. cit.
[67] Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm*; loc. cit.
[68] United States Senate Committee on Energy and Natural Resources, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future* [on-line]; available from http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1505&Witness_ID=4283; Internet; accessed on 11 April 2006
[69] National Science Foundation, *America’s Pressing Challenge – Building a Stronger Foundation* [on-line]; available from http://www.nsf.gov/statistics/nsb0602/; Internet; accessed on 23 February 2006
[70] ibid.; pp. 3 - 4

Australia

Australia would do well to follow the US lead. An audit of science, engineering and technology (SET) skills being undertaken by the Australian Government has identified significant skill shortages in these fields, particularly engineering, earth sciences, chemistry, spatial information science, entomology, mathematics and statistics. These shortages are predicted to worsen in the face of declining and/or stagnant enrolments in SET fields at all levels of education; increased domestic demand for skills in engineering and the enabling sciences resulting from economic development; increasing global demand for highly skilled labour; ageing of the workforce; and a high rate of loss of personnel in the science and engineering professions and trades to other occupations.[71]

A study commissioned by Macquarie University in 2006 found that high achieving school leavers are opting out of the sciences in favour of courses that promise more lucrative careers.[72] The study included a survey of 1,300 high school students, 300 current Macquarie students, over 70 professional scientists, and employers. They survey identified that students focus on careers when choosing a study area, but have very limited understanding of SET careers, and that enthusiastic science teachers strongly influence students choosing SET study.[73]

Higher Education

There is the belief held by the working group that the quality of our university degrees is declining. We need to ensure that quality is not further jeopardized through inadequate funding.

> "The quality of Australian university degrees is our tradeable currency."
>
> Professor Ian Chubb, Vice-Chancellor, Australian National University

In higher education, domestic enrolments in SET courses as a proportion of total enrolments, has declined from 15.8 per cent in 1989 to 14.0 per cent in 2004. Much of the decline occurred in engineering, agriculture, environment and related studies, while the proportion in natural and physical sciences has remained static. Over the same period, the proportion of overseas students undertaking SET courses in higher education as a proportion of total enrolments rose from 1.6 per cent to 3.2 per cent.[74]

Skill shortages are creating serious concerns within Australian industry that may not have the ability to sustain our current position as a knowledge economy, let alone improve it.

[71] Paul Mills, Director, Skills Analysis Section; DEST, presentation to the working group, 19 September 2005; loc. cit.
[72] Brendan O'Keefe, *Science Shunned for Money*; The Australian; 12 April 2006
[73] Professor John Loxton, *Science, Engineering and Technology Study*; Deputy Vice Chancellor Academic, Macquarie University; presentation to the 2006 Macquarie University Careers Advisers Day; 6 March 2006
[74] Paul Mills, Director, Skills Analysis Section; DEST, presentation to the working group, 19 September 2005; loc. cit.

Commonwealth grants to universities from 1996 to 2003 increased by 6 per cent in seven years; from $4.6 billion to $4.9 billion. Student to staff ratios are often cited as another key quality input benchmark. Between 1993 and 1999, staff numbers in universities rose by only 1 per cent while student numbers rose by 19 per cent. Consequently, student/teacher ratios rose substantially, from 14.2:1 in 1993 to 18.3:1 in 1999. Academic staff numbers began to rise again in 2000, but student/teacher ratios continued to increase until 2003, reaching 20.1 in 2003 before falling in 2004 to 19.8[75] (see also Figure 1.14 Appendix 1).

Recent funding increases, including *Backing Australia's Ability* and *Backing Australia's Future* (see Appendix 3 for further information) initiatives were a welcome contribution and have made a positive impact. As part of the *Our Universities: Backing Australia's Future* higher education reforms in 2005, 216 new Commonwealth supported engineering places were allocated to Australian higher education providers, growing to 591 new ongoing engineering places by 2008. The Australian Government has also allocated an additional 40 commencing places in engineering (including 5 in mathematics and statistics) to the Queensland University of Technology in 2006. These places will grow to 110 places by 2009. These new places are part of a reallocation of a number of places to Qld universities and represent 100% of the places in engineering requested overall. In addition, as part of the 2006-07 Budget, the Government is providing additional funding of $95.5 million over four years through the Capital Development Pool (CDP) to assist higher education providers with capital projects. This represents a 50% increase in the base funding available to the higher education sector through this programme.

However, the universities need substantial discretionary funding to address their global competitiveness and capture opportunities. They need this funding to build world class infrastructure that will attract the best researchers in their field; to support the best possible teaching at our universities; and to ensure they have the most technologically advanced teaching and research support. In particular, Australia needs to urgently re-invest in science and engineering, and challenge our universities to use these additional funds to improve their international standing.

Overseas student enrolments have provided a vital source of funding for universities in the last ten years. This has also been a significant part of Australian service exports. Overseas students also have the potential to become a source of skilled labour. Indeed many overseas students see taking an education programme in Australia as a valuable contribution to their migration aspirations. This creates additional pressure on seeking to ensure that those students are of the highest quality.

China and India are by far the largest source of postgraduate overseas students studying in Australia. Together they accounted for 54 per cent of all overseas postgraduate enrolments in 2005. The next biggest source is Bangladesh, which accounted for only a tenth of those coming from China or India.[76]

Graduates of India's elite Indian Institutes of Technology (IITs) are being actively recruited into the US. IITs accept less than 1 per cent of their 250,000 applicants each year, compared to an acceptance rate of more than 10 per cent for the best US universities. In 2000, IITs occupied five of the first eight places in the Asiaweek survey of S&T universities in Asia.

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[75] *Draft OECD Thematic Review of Tertiary Education: Country Background Report Australia*; DEST; Canberra; 2006

[76] *Year 2006 Market Indicator Data*, Department of Education, Science and Training, February 2006

The Australian situation is the reverse: there is a significant shortfall in demand for natural and physical science courses by high achieving school leavers. The AVCC *Report on Applications for Undergraduate University Courses* for 2006 found that of eligible applicants who achieved 90.05 or higher on the Interstate Transfer Index for 2006, 121 per cent received an offer of a university place. This is in contrast to the oversubscription in medical studies and law, where 59 and 80 per cent of eligible applicants respectively received an offer.[77]

An estimated 30 per cent of graduates from IIT Madras went to the US in 1998, and together with Indian companies from Silicon Valley created start-up businesses throughout India. The Global IIT Alumni, established in Silicon Valley held its second conference in 2005, with the aim of fostering joint research between the IITs and US industry, academia and government and promoting networking among alumni. [78] See Appendix 11 for more information on IITs.

The working group recommends that the Government enhance Australia's status as a preferred destination for the best Chinese and Indian postgraduate students by offering scholarships and exchanges, linking with the best global institutions, supporting alumni links and providing courses where part of the study is done in Australia and part in China/India. It also recommends that remaining barriers be removed to these students and researchers travelling to and working and living in Australia.

Australia's publicly funded research agencies (eg CSIRO, AIMS, ANSTO) have a role to play in training and capacity building as well as the universities. These agencies train Australian and foreign graduate students and postdoctoral researchers and should be supported in growing this effort.

Support for R&D needs to be focused on excellence, wherever it occurs, and on expanding areas and groups that are, or can attain the highest quality. Quality should be defined in terms of real economic and social outcomes, and not only in purely academic terms, and should be supported wherever it is found.

Secondary Education

A review of teaching conducted by the Australian Government in 2003 identified an absence of a pervasive culture of innovation in Australian schools, relatively poor or little teaching of science in primary school, relatively poor student engagement in learning of science, technology and mathematics in the middle years, and a declining proportion of students continuing studies in science and mathematics to advanced levels in secondary and tertiary education.[79] It highlighted the need to ensure an adequate supply of highly talented, well-educated science, technology and mathematics teachers.

In 2005 the Government launched the $33.7 million Australian School Innovation in Science, Technology and Mathematics (ASISTM) programme to revitalize teaching and learning in these fields. The programme fosters new approaches through grants of between $20,000 and $120,000, and employs around 1300 teacher associates such as university students, researchers and other specialists in these fields, who will provide project support, excite students' interest and act as role models.[80]

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[77] Australian Vice-Chancellors' Committee, *Report on Applications for Undergraduate University Courses*; AVCC; May 2006

[78] *UNESCO Science Report 2005*; p. 250

[79] Committee for the Review of Teaching and Teacher Education, *Australia's Teachers: Australia's Future - Advancing Innovation, Science, Technology and Mathematics*; Commonwealth of Australia, Department of Education, Science and Training; October 2003

[80] The Hon. Julie Bishop MP; *Revitalising Science, Technology and Maths Teaching* [on-line]; available from http://www.dest.gov.au/Ministers/Media/Bishop/2006/04/b001060406.asp; accessed 6 April 2006

Building on *Backing Australia's Ability* and *Backing Australia's Ability - Building our Future through Science and Innovation*, Australia needs to urgently re-invest in higher education, particularly in science and engineering research, and challenge our universities to use these additional funds to improve their international standing. We need to press on with reforms to raise the quality of Australia's education system to generate the skills needed to take a global leadership role in science, technology and engineering and support our schools and teachers to meet this challenge.

Recommendation 3

Strengthen the foundations of Australia's education system by increasing the investment in higher education, attracting higher quality Australian students into science and engineering, strengthening the science and maths teaching and curricula in Australian schools, and attracting higher quality doctoral students from China and India.

The increase in investment in Australia's best universities should focus on reducing staff-student ratios and attracting lead researchers from overseas, and creating world class research facilities. The working group believes that this investment will ensure that they remain internationally competitive in science and engineering.

Attracting the highest quality Australian students into science and engineering will help strengthen Australia's science and engineering capability. This can be accomplished by increasing entry level requirements for science and engineering courses, providing scholarships and HECS incentives at undergraduate and postgraduate levels. In addition, support cadetships and interns in industry on graduation.

Strengthening science and maths curricula and teaching capability in Australian schools is also critically important. Raising the quality of science and maths teaching in secondary schools can be achieved through scholarships for science and maths teacher education, supporting the development of science secondary schools linked to major research facilities, and encouraging the academies and professional societies to assist secondary schools in building enthusiasm for science.

Attracting the best (from the top 2 per cent) postgraduates and post doctoral researchers/fellows from China and India into Australian research organisations and universities will further strengthen Australia's research capability. This will create opportunities for Australian students and researchers to work alongside some of the best in the world and to develop networks for future collaboration. It can be accomplished by offering scholarships and exchanges to both Australian and overseas students, linking with the best global institutions, supporting alumni links and providing courses where part of the study is done in Australia and part in China/India. To facilitate this process, immigration barriers to the best students and researchers travelling to and working and living in Australia should be removed.

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