The Contribution of Science and Technology to Australia's Balance of Payments to the Year 2000 – The Primary Sector

1989
The Australian Science and Technology Council (ASTEC) is a statutory authority of the Commonwealth Government. The Council is the Government's principal source of independent advice on a wide range of policies and programs related to science and technology. The fifteen members of the Council are drawn from science, industry and the trade union movement. They are supported by a full-time secretariat.

ASTEC provides advice to the Government through formal reports, which are tabled in the Parliament, and by letters and briefing notes sent to the Prime Minister. In addition to this formal advice, members of the Council and the secretariat produce occasional papers on subjects of general interest in the area of science and technology. These papers are intended to stimulate discussion and debate on significant scientific, technological, economic and social issues.
1 Key Technologies and their Role in Economic Development of Small Countries by W J McG Tegart, May 1988

2 Superconductivity by I R Shortt, July 1988

3 After the Myers Report: Improving the Management of Technological Change, August 1988

4 Government Purchasing Policy and Industrial Innovation, October 1988

5 The Contribution of Science and Technology to Australia's Balance of Payments to the Year 2000 – Service Sector, January 1989

6 Commentary on the ASTEC Review of CSIRO, Geoffrey Oldham, December 1988

7 The Contribution of Science and Technology to Australia's Balance of Payments to the Year 2000 – Manufacturing Sector, February 1989

8 The Contribution of Science and Technology to Australia's Balance of Payments to the Year 2000 – Primary Sector, June 1989
The escalation of Australia’s level of foreign debt in recent years has highlighted the need for structural changes to the nation’s economy, so that the production of goods and services is more closely attuned to the demands of domestic and overseas customers. Greater export orientation, import replacement and overseas investment will be required of industry if the nation is to reduce its foreign indebtedness.

There are many factors which will contribute to improved competitiveness of the Australian economy; the development and application of new technologies is one of these factors. Product innovation, embodied in new or improved devices, and process innovation, which acts to increase the efficiency of production, both influence industrial competitiveness. New technologies also enhance the range of final services available to consumers and the input of intermediate services to the production of goods in other sectors of the economy.

ASTEC is undertaking a study of the contribution that science and technology could make to Australia’s economic development and balance of payments situation to the year 2000. This study will examine the perceived growth potential of economic sectors, the role that science and technology could play in such growth, and the barriers to maximising these market and technological opportunities.

Studies relating to primary, manufacturing and service sectors are being conducted. An Overview Report will develop further the findings of the separate sector studies and will highlight factors likely to have a pronounced influence on international and domestic markets, sectoral linkages and major science and technology issues.

This Occasional Paper covers ASTEC’s review of the primary sector. The emphasis in this paper is on science and technology, predicated on ASTEC’s assessment that science and technology is an essential element in Australia’s current and future economic development. However, it is important to recognise that the full benefits of science and technology will be achieved only if the overall economic environment is favourable. Thus, this paper also focuses on those domestic and international factors which help shape Australia’s economic conditions, and in turn determine the impact of science and technology.

Comments on this and the other papers reporting on this study are welcomed and should be addressed to:

The Secretary
Australian Science and Technology Council
PO Box E439
Queen Victoria Terrace
CANBERRA ACT 2600
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Change in the Primary Sector

Australia is not immune to the various changes taking place in the complex global economy. Sixty-nine per cent of Australia's total exports of goods and services are primary products and these products are amongst the first to feel the effects of global economic conditions and respond to them. This is unlikely to change.

Agriculture's share in world trade has declined over the past 40 years following increases in manufacturing and service trade and elevated levels of agricultural protectionism. The decline in agricultural trade is expected to stabilise in the longer term and possibly increase as Japan and several of the newly industrialised Asian countries liberalise their trade barriers and become more significant importers of food. Minerals and energy commodities can be expected to maintain their share of world trade over the next ten years. The international trading environment is likely to be characterised by the continuation of protectionist policies in agriculture in the European Community (EC) with a subsequent increase in trade tensions, and the gradual trend towards the establishment of major economic trading blocs which have the potential to raise trade barriers.

Growth prospects of the newly industrialising countries in Asia look promising and the outlook for Australia's primary products in these markets appears optimistic. Despite a variety of trade barriers, particularly for agricultural products, the market potential in the EC and the United States (US) should not be discounted. Short-term fluctuations in the exchange rate which distort market signals in the economy are likely to continue to adversely affect the competitiveness of Australia's primary sector industries; as will other factors such as high-cost, inefficient transport services and restrictive management and work practices, if remedial action is not taken. In contrast, foreign investment offers the opportunity for continued improvements in trade performance and the introduction of high level skills and new technology.

Australian Primary Industries

The changes to individual agricultural industries in Australia will be, in ASTEC's opinion, highlighted by the following trends:

- **Wool**: The wool industry can expect increased competition from cotton and synthetic fibres. There will be limited scope for adding significant value to the wool clip through the export of yarns and fabrics, especially while the Australian textile manufacturing and clothing industry receives substantial levels of assistance. Technological advances are likely to occur in, for instance, scouring and spinning techniques, genetic improvement of sheep and pasture improvement.

- **Meat and Livestock**: The market potential for beef exports is considerable. Realisation of this potential will depend on continued economic growth in Asia. The development and introduction of automated slaughter technology is likely within the next decade. Other productivity improvements can be expected through integration of imported breeds in Australia's northern beef herd, the genetic evaluation of cattle, the development of new products for export (e.g. fermented meat products), improved packaging techniques and by-product processing.
• **Grains:** Australia is geographically well placed to service markets in Asia, especially China, which offer the greatest potential for export growth of wheat. Overseas markets are expected to increasingly demand grain with well-defined properties. Breeding programs will be tailored to meet market requirements. Ninety percent of Australia's grain exports are unprocessed and one possible area for growth is gluten products.

• **Horticulture:** Australia has the opportunity to further exploit its advantage of being able to supply fresh horticultural crops out of season to northern hemisphere markets, provided handling, transport, storage and marketing technologies are sufficiently integrated and improved. Promising opportunities exist in the increased export of wine and table grapes, the development of a cashew growing industry and the expansion of ornamental horticulture. The potential for exploiting the food and medicinal properties of Australia's native species has been virtually ignored – a wide-ranging research effort is needed.

• **Sugar:** Gradual growth in sugar exports is expected. Research into maintenance of capital equipment, harvesting, disease and pest control, and cultural practice are likely to result in increased production efficiency. Higher yielding canes with better resistance to disease and weather stress can be expected by the turn of century. Value adding opportunities will be realised by the increased export of products containing sugar, such as dairy foods, alcoholic and non-alcoholic beverages and bakery products.

• **Forestry:** The forest sector currently faces a trade deficit of $1.4 billion. Opportunities exist to reduce this deficit through the development of domestic pulp and paper processing facilities. Import replacement opportunities also exist in the use of eucalypt and pine to produce veneers in plywood production. Hardwood plantations are expected to gradually reduce the dependence of the industry on oldgrowth native forests.

• ** Fisheries:** With improved handling, further processing and better marketing, fisheries exports have the potential to reach $1 billion by the year 2000. Import replacement is possible by developing Australia's tropical and deepwater fisheries, and by making better use of local underutilised fisheries. The potential of aquaculture is uncertain, but the industry will not be exploited unless a medium term research marketing and business development strategy is implemented.

Changes to individual minerals and energy industries will be highlighted by the following trends:

• **Iron Ore:** Iron ore consumption will grow at a rate marginally below steel consumption due to continuing development of scrap based mini-mills. Australia should maintain its market share and be able to increase its share of the incremental demand in the regional area, particularly if an improved reputation for supply reliability could be achieved. Product upgrading and differentiation in processing and upgrading iron ore will reduce chemical and physical impediments using higher components in blends and reduce utilisation costs for consumers. Further focus on adding value, through agglomeration and development of new technology such as HiSmelt will aid Australia's competitiveness.
• **Aluminium**: Australia is the world's lowest cost alumina producer and will expand its market share in the Asian region where consumption is expected to grow strongly. The potential for growth in aluminium metal exports is considered to be strong. Australia could virtually double its aluminium exports by the year 2000, from $1.2 billion to $2.2 billion. Increasing emphasis on later stage processing of aluminium before export is expected to continue.

• **Gold**: It seems likely that the re-emergence of gold as a major export industry will suffer a downturn in the 1990s if the gold tax is introduced, as planned, in 1991. The major mines will survive, but the replacement of short life mines, which constitute a significant proportion of the total number of mines, will be discouraged. Advances can be expected in exploration, ore-targetting and drilling techniques, as well as in mining automation.

• **Base Metals**: Increased market share in copper is predicted. Markets for zinc and lead are expected to increase and a new smelting process, Isasmelt, will reduce production costs for lead and zinc processing. Australia's nickel producing capacity will decline unless new finds are made.

• **Mineral Sands**: Demand is predicted to continue to be strong for titanium dioxide pigment, which is widely used in the paint, papers and plastics industries. Australian capacity for synthetic rutile and pigment production is expected to expand. Significant opportunities exist for the processing of monazite into rare earth compounds but Australia has difficulty obtaining access to suitable technology.

• **Diamonds**: The export potential of this new, robust industry is good, especially in the US, Japan and Asia. New diamond finds will be important in increasing the value of Australia's exports. New technologies will be applied to reduce processing difficulties in the production of near-gem diamonds, with subsequent gains in diamond values.

• **Magnesium**: Australia's involvement in the world magnesite industry has only been minor. However, with the discovery of a large magnesite deposit in Queensland, this situation has the potential to change. The establishment of a magnesite processing plant could lead to other developments, including the production of magnesium metal (currently fully imported) and calcined magnesia for filtration purposes.

• **Coal**: Despite uncertainty about environmental concerns, world steaming coal demand is likely to double by the year 2000. Australia will face increasing competition to maintain its market share. There will be the introduction of more efficient and environmentally much less polluting technologies for coal sourced electricity generation. The development of very clean, high density coal slurries over the next 10 to 20 years is likely to replace heavy fuel oil in power stations and industrial boilers.

• **Uranium**: Uranium demand not yet committed to contracts will rise with a concomitant decline in inventory stocks. The complex issues of export limitations and processing of uranium beyond the yellow cake stage before export are being considered by a Government review.
• Oil and Gas: Australia will be facing a massive liquid fuel import bill by the year 2000. To alleviate this problem, Australia will have to: implement a tax regime conducive to increased oil exploration activity; examine the prospects for the production of synthetic liquid fuels from natural gas and coal; and pursue research in energy efficient transport technologies and renewable energy sources. The prospects for value adding in the gas industry are good, with the first exports of liquified natural gas expected later this year.

Research and Development

Although recent Government policy has emphasised support of manufacturing R&D, the primary sector industries, apart from the energy industries, have maintained a positive real rate of R&D expenditure growth. The balance between basic and applied research in agriculture is still being worked out in Australia. The interdependence of basic and applied research in agriculture is in danger of being overlooked. In the minerals and energy industries, the state of geology research in Australia is of particular concern. Earth sciences research is fragmented, spread too thinly and lacks a logical national framework for its conduct. The returns from investment on research are coming under closer scrutiny as a means of aiding the allocation process for research funds and helping to convince the private sector there is value in investing in research.

Future directions for the Primary Sector

Provided the primary sector is able to respond with sufficient speed to changed national and international circumstances, the future of the sector appears to be sound. Science and technology will continue to play a key role in productivity improvement in the primary sector. The primary sector, like all sectors of the economy, will require a strong and vigorous skills base as a prerequisite to utilising technology and optimising competitiveness.

Key issues facing the sector in the next decade are:

• international trading environment;
• environmental management and development
• industry competitiveness;
• further processing of raw materials; and
• energy revenues.
Against a background of escalating foreign debt and a worsening balance of payments position on the current account, the aim of this study is to examine the contribution that science and technology can make to the future development and prosperity of Australia's primary sector industries in the medium to long-term. To facilitate this aim, terms of reference were developed and these are listed in Appendix A.

1.1 Report structure

Chapter 2 describes, using several indicators, the size and composition of the primary sector industries and their contribution to Australia's economic development. It then focuses on recent overall trends in the sector.

A number of important external and internal factors which determine the overall economic environment for the primary sector industries and their science and technology support are discussed in Chapter 3.

Chapter 4 highlights significant trends and future prospects for a range of primary sector industries, emphasising the role to be played by science and technology.

The importance of research and development (R&D) for the continued development and prosperity of the primary sector is discussed in Chapter 5; recognising that R&D is a key element in technological development and implementation.

The final Chapter outlines the major issues facing the primary sector, and discusses the general scientific and technological implications of these issues for the future of the sector.

1.2 Study procedures

In accordance with ASTEC's usual procedures a Working Party was appointed to execute the study. Members of the Working Party and its activities are detailed in Appendix B.

The study involved a survey of the literature and field work. The latter consisted of interviews and information gathering from senior representatives of private companies, tertiary institutions and Federal and State government departments and agencies.
CHAPTER 2
THE PRIMARY SECTOR:
ITS CONTINUED IMPORTANCE TO THE AUSTRALIAN ECONOMY

Australia's primary industries have been vital to the successful development of the economy over the past 200 years. These industries will continue to be the backbone of the economy in the next ten years and well into the 21st century.

2.1 Contribution to the economy

Direct measures of the contribution to GDP and employment by the primary industries significantly understate the importance of these industries to the economy. This is because the generation of GDP and employment in other areas of the economy, dependent upon or associated with the primary industries, is not included. For example, it has been estimated\(^1\) that without including transport and finance, agriculture and associated industries employ about 1.4 million people or about 20 per cent of the workforce. This same group of industries added value to the agricultural raw materials of around $30 billion. A recent study\(^2\) shows that in the mining industry, each job creates at least 1.7 additional jobs elsewhere in Australia in associated businesses, which means that the mining industry accounts for about 7.2 per cent of the workforce. The same study indicated that there are substantial flow-on benefits generated by the mining industry in terms of wages, salaries and product sales. It estimated that every dollar received for minerals sold generates goods and services of $1.70 as it works its way through the economy.

The close integration of the primary industries with the manufacturing and service industries can be seen very clearly in the manufacturing sector. Here, the primary sector provides the inputs for the two largest components of the sector, the food and beverage industries (20 per cent of the sector) and the basic metal products industries (13 per cent of the sector), both of which have the highest export orientation of all the manufacturing industries. Overall, about two thirds of the gross production of the manufacturing sector is based on transforming agricultural and mining products.

Infrastructure development is an important indicator of the contribution to the economy by the primary sector. The primary industries have been, and will continue to be the driving force behind the development of Australia's non-metropolitan infrastructure. The primary industry activity which stimulates the construction of railways, roads, airfields, ports, harbours and towns, and the creation of jobs in the industries undertaking such construction, is frequently not given the recognition it deserves, particularly for the consequent economic growth.

2.2 Export role

In the past, Australia has relied heavily on its primary industries to generate export revenue. This dependence can be expected to continue in the longer term. Figure 2.1 shows that in 1987–88, the primary industries accounted for 69 per cent ($33.4 billion) of Australia's total exports of goods and services. The figures used to generate these statistics include both unprocessed primary products and processed items predominantly of primary origin, such as meat and dairy products, canned fruit, alumina and aluminium, and petroleum products.
Figure 2.1: Contribution to Australian Exports, by Sector

1969-70

Total exports: $4749 million

- 45.6%
- 15.8%
- 11.9%
- 26.7%

(a) Includes forestry & fisheries products
(b) Includes metal ores & minerals, fuels & metals
(c) Largely machinery & transport equipment, chemicals & highly processed manufactured goods

1987-88

Total exports: $48753 million

- 38.2%
- 31.3%
- 16.7%
- 13.8%
The mix between the contributions of the agricultural and resource sector industries has changed over the past 20 years (see Figure 2.1). Agriculture's share of exports has declined, as the shares of the resource and service sector and other merchandise exports have increased. However, the absolute value of agricultural exports has increased almost sevenfold during this time.

Australia's dependence on agricultural exports is unusual for a developed country. This is partly a consequence of our competitive and flexible agricultural industry optimising its use of extensive land resources and a generally favourable climate, and partly a result of Australia's poor performance as an exporter of manufactured goods in post-World War II years. The increase in the contribution of the resource sector industries to Australia's export income stems from the mineral discoveries of the 1960s followed by the very rapid expansion of the sector in the 1960s and 1970s. The resource sector industries are now Australia's leading export earner.

The majority of Australia's primary commodity exports are accounted for by a relatively small group of commodities (see Table 2.1). In 1987–88, wool, beef and veal, wheat, coal, alumina, aluminium, gold and iron ore accounted for about two-thirds ($21.9 billion) of Australia's exports of primary origin. Other significant value exports included sugar, dairy products, forest products, fisheries products, crude oil, uranium and the base metals (copper, lead, nickel and zinc).

### Table 2.1 Australia's Primary Sector Exports For 1987-88

<table>
<thead>
<tr>
<th>Category</th>
<th>Value ($m)</th>
<th>Share of total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farm Crops</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1795</td>
<td>5.4</td>
</tr>
<tr>
<td>Sugar</td>
<td>669</td>
<td>2.0</td>
</tr>
<tr>
<td>Other cereal grains &amp; oilseeds</td>
<td>407</td>
<td>1.2</td>
</tr>
<tr>
<td>Raw cotton</td>
<td>353</td>
<td>1.1</td>
</tr>
<tr>
<td>Barley</td>
<td>282</td>
<td>0.8</td>
</tr>
<tr>
<td>Fruit</td>
<td>211</td>
<td>0.6</td>
</tr>
<tr>
<td>Total major crops</td>
<td>3717</td>
<td>11.1</td>
</tr>
<tr>
<td><strong>Meat &amp; live sheep for slaughter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef &amp; veal</td>
<td>1958</td>
<td>5.9</td>
</tr>
<tr>
<td>Other</td>
<td>349</td>
<td>1.0</td>
</tr>
<tr>
<td>Live sheep</td>
<td>221</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>2538</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Livestock products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>5711</td>
<td>17.1</td>
</tr>
<tr>
<td>Dairy</td>
<td>521</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>6232</td>
<td>18.7</td>
</tr>
<tr>
<td><strong>Other farm exports</strong></td>
<td>1609</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Total farm exports</strong></td>
<td>14,086</td>
<td>42.2</td>
</tr>
<tr>
<td><strong>Forest products</strong></td>
<td>465</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Fisheries products</strong></td>
<td>724</td>
<td>2.2</td>
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<tr>
<td><strong>Mineral resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
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<tr>
<td>Coal</td>
<td>4754</td>
<td>14.2</td>
</tr>
<tr>
<td>Crude oil</td>
<td>974</td>
<td>2.9</td>
</tr>
<tr>
<td>Other</td>
<td>837</td>
<td>2.5</td>
</tr>
<tr>
<td>Uranium</td>
<td>411</td>
<td>1.2</td>
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<tr>
<td>Liquid petroleum gas</td>
<td>243</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>7219</td>
<td>21.6</td>
</tr>
<tr>
<td><strong>Metalliferous minerals &amp; metals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>2,415</td>
<td>7.2</td>
</tr>
<tr>
<td>Iron ore &amp; pellets</td>
<td>1,832</td>
<td>5.5</td>
</tr>
<tr>
<td>Aluminium (ingot metal)</td>
<td>1,761</td>
<td>5.3</td>
</tr>
<tr>
<td>Alumina</td>
<td>1,702</td>
<td>5.1</td>
</tr>
<tr>
<td>Zinc</td>
<td>581</td>
<td>1.7</td>
</tr>
<tr>
<td>Lead</td>
<td>545</td>
<td>1.6</td>
</tr>
<tr>
<td>Nickel</td>
<td>530</td>
<td>1.6</td>
</tr>
<tr>
<td>Other</td>
<td>477</td>
<td>1.4</td>
</tr>
<tr>
<td>Copper</td>
<td>402</td>
<td>1.2</td>
</tr>
<tr>
<td>Mineral sands</td>
<td>367</td>
<td>1.1</td>
</tr>
<tr>
<td>Diamonds</td>
<td>290</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>10,902</td>
<td>22.6</td>
</tr>
<tr>
<td><strong>Total mineral resources exports</strong></td>
<td>18,121</td>
<td>54.2</td>
</tr>
<tr>
<td><strong>TOTAL PRIMARY SECTOR EXPORTS</strong></td>
<td>33,396</td>
<td>100.0</td>
</tr>
</tbody>
</table>
2.3 Balance of trade

Without the high export orientation of the primary sector industries, Australia's poor balance of payments situation would be greatly exacerbated. Figure 2.2 shows that the primary sector trade balance over the past eight years has been positive and greater than 4 per cent of GDP during that time. This is in stark contrast to the manufacturing sector's trade balance which has deteriorated dramatically since 1980 and although currently on an upward trend is still in deficit at about minus 5 per cent of GDP.

Figure 2.2: Australia's Trade Balance in the Primary & Manufacturing Sectors

Further examination of the balance of trade position for the primary sector in 1987–88 reveals two issues of importance:

- The margin by which crude oil imports exceeded exports was close to $0.5 billion. This deficit is predicted to increase rapidly, and by the year 2000 could be as high as $5.3 billion (in 1988 dollars), raising major implications for Australia's transport fuel use and balance of payments position.

- The forestry industries had a net trade deficit of $1.4 billion, largely a consequence of the importation of $1.2 billion of pulp and paper products.

These points will be examined in further detail later in this paper.
2.4 Recent trends

A major structural trend in the agricultural industries has been the reduction in the number of farms and an accompanying increase in the physical size of farms. A concurrent trend has been the increase in the scale of operation of farms. As farms have become physically larger, sheep and beef cattle numbers have risen significantly as has the total area dedicated to crops and sown pastures and grasses.

The predominant form of farm ownership is the family partnership, and this is likely to continue for the foreseeable future. An important structural factor in the farm sector is the significance of off-farm income. Several studies indicate that off-farm income has been important to farmers in the broadacre, dairy and horticultural industries throughout the 1980s. A further factor is the increase in hobby or part-time farmers — those people whose major source of income is off-farm.

Significant restructuring has occurred in the minerals and energy industries. Company takeovers have resulted in a reduction of the number of enterprises, particularly in the oil and gas industries. The most recent example of concentration has occurred for the ore–based metals at Broken Hill, where North Broken Hill and CRA amalgamated their activities, forming Pasminco. The number of companies in the coal industry appears likely to be reduced in the near future in light of intense competition and oversupply. A notable exception to the trend for rationalisation by concentration is in the gold industry. Here the number of enterprises has increased substantially in response to the advent of technology permitting the exploitation of reserves in a large number of small mines.

Production patterns have changed in the primary sector in recent years. In agriculture, the paramount importance of wool, wheat and meat has remained unchanged. However, the agricultural industries have shown a ready capacity to switch between products in response to market trends. For example, farmers have switched from wheat production to wool production in the past few years, the reverse of the trend evident in the early and mid 1970s. The mix of products being exported has diversified. The most prominent change has been in the grain legumes, especially lupins and field peas, where exports have increased at a very rapid rate throughout the 1980s, albeit from a low base.

In the minerals and energy industries, the importance of coal, alumina and aluminium as export earners has increased markedly during the 1980s. The export of aluminium is an excellent example of the general increase in value added output as a result of a higher manufacturing component. The mix of products has become broader with the addition of synthetic rutile and industrial diamond production. The re-emergence of gold as a major export earner has been a bonus to the sector. Following a dynamic period of growth since 1982, gold is now the third largest minerals and energy export after coal and alumina and aluminium.
3.1 Introduction

It is important to recognise that the full benefits of science and technology will be achieved only if the overall economic environment is favourable. The overall economic environment is determined by a complex mix of policies derived from both the external and internal environment. This chapter outlines those issues which are judged likely to have the greatest impact on the economic environment for the primary sector over the next decade.

3.2 External environment

Australia is a part of a global economy which is characterised by an increasingly interdependent and interrelated network of goods and services flows. The complex linkages which exist mean that major economic developments which occur in one part of the world will have an impact on other parts of the world. These linkages, which are becoming stronger and occurring at an accelerating rate are due, in part, to the increasing internationalisation of business enterprises, including Australian industries, and the speed with which information is transmitted around the world via an extremely efficient global communications system.

Australia is therefore not immune to the various changes taking place in the global economy. Its exports, which currently amount to about 16 per cent of GDP, are directly affected by economic and environmental developments occurring elsewhere in the world, particularly as 69 per cent of Australia's exports of goods and services are primary products. History shows that primary products are amongst the first to feel the effects of changing global economic conditions. This is unlikely to alter. In Australia, because the primary sector exports such a large part of its product, it, more than any other sector of the economy, has had to respond rapidly to changing global economic conditions; and it has, with great efficiency.

The 'global economy' consists of a diverse range of countries at different stages of economic development, providing opportunities for trade in a variety of goods and services. The extent and nature of such opportunities is changing all the time and is influenced by political developments as well as demand and supply considerations. Agriculture's share of world trade has fallen over the past 40 years partly as a result of increases in world manufacturing and service trade (which include a significant agricultural value-added component) and partly as a result of increased levels of agricultural protectionism. Agriculture's current share of world trade can be expected to be maintained and possibly increase in the longer term as Japan and several of the newly industrialised Asian countries liberalise their agricultural trade barriers and become more significant importers of food. World trade in minerals and energy products has fluctuated around an average share of 15 per cent since World War II. Major deviations from this trend mirrored the oil price hikes of the mid 1970s and early 1980s. Although there will be pressure from less intense usage, substitution and new approaches to functional design, minerals and energy commodities can be expected to maintain their share of world trade over the next ten years, but with some significant year-to-year variations caused by price fluctuations.
World primary commodity trends need not dictate the benefits that can accrue to Australia. An increase in Australia's share of world primary commodity trade need not occur only when world commodity trade is increasing, but can equally occur when, and need not be inconsistent with, a decline in that trade.

3.2.1 Market access

World trade in primary commodities is currently severely distorted by several constraints which significantly reduce market access. Small exporting countries like Australia suffer the most from limitations on market access.

Government intervention, through the erection of trade barriers and domestic protectionist policies have increased dramatically in recent times. These practices lead to misallocation of resources and contribute to global overcapacity of commodity production, dampen prices and contribute to unfair competition in third markets.

An example of government intervention in the minerals and energy area is in the European Community (EC), where the Federal Republic of Germany subsidises domestic coal production to the extent that the subsidies are of nearly the same value as Australia's coking coal exports.

The major area of government intervention has been in agriculture where protectionist policies in both developed and developing countries are of concern. A recent study examined grains, meat, dairy products and sugar, which amount to about half of world food trade, and measured the effects of the protectionist policies of Western Europe (mainly the EC) and East Asia on the traditional food exporters of Australia and North America. The aggregate cost of these policies is about US$26 billion a year, with the EC's Common Agricultural Policy the major contributor. The losses per farm are also enormous. The study indicated that the loss per Australian farm could be as high as A$30,000. Clearly, any liberalization of these protectionist policies has great significance for Australia's agricultural exports.

The major forum for negotiations on international trade is the General Agreement on Tariffs and Trade (GATT). In principle GATT is directed at both reducing existing trade barriers and preventing the construction of new ones. Despite progress in trade policy directions at the recent GATT negotiations in Geneva, little real progress has been made in achieving liberalisation of agricultural trade. This lack of progress is certainly not through any lack of effort or expertise of the Australian Government. The Government is trying to ensure trade reform by bringing the costs of agricultural protectionism to the notice of the countries where such policies are in place, and pursuing discussions aimed at liberalising agricultural trade in the latest multilateral trade negotiations round of GATT. To this latter end, the Government was instrumental in the formation of the Cairns Group of free trading countries in 1986, as a means of more effectively participating in the negotiations. If the attempts of Australia and like-minded countries to liberalise trade through GATT are not successful, then a likely scenario will be the cementing and perhaps escalation of protectionist pressures in developed and developing countries. As a consequence there would be an increase in trade tensions, manifested in bilateral trade frictions with a tendency for discriminating bilateral trading arrangements. Australia's market access, and hence market share, could be restricted, resulting in a reduction in returns from commodity exports and a more severe impact on our balance of payments position.
Other market access restraints include tariff and non-tariff barriers. The issue of chemical residues in food has become important as a determinant of market access. Government decisions to ban food imports will be related to monitoring of chemical residues and continuing consumer acceptance of internationally agreed minimum recommended chemical residue levels. This has implications for the food quality standards of all food producers, including Australia. Restraints on market access can arise from unexpected sources, with mixed implications for Australia. For example, the Chernobyl disaster has adversely affected trade in beef and dairy products sourced from EC and Soviet bloc countries. Australia, by geography and circumstance has benefitted and can continue to benefit by promoting its products as radiation free.

### 3.2.2 Trading blocs

Increasingly the world is moving towards a situation of four major economic trading blocs: North America, the Asia-Pacific, Western Europe and the Soviet bloc. Formal regional trading blocs are aimed at increasing intra-regional trade, but also have the potential to raise trade barriers with countries which are not a part of the bloc. It is important for Australia to closely monitor the development of the various trade alliances leading to trading blocs, for example, the EC post 1992, the European Free Trade Association and the United States/Canada free trade agreement. Because it will be such a powerful trading bloc, the EC's approach to liberalisation of trade will be an important determinant of multilateral trading relationships in the future. Australia is however, not just sitting back and watching these developments. There has been considerable action by Australian businesses to position themselves in Europe for post 1992.

Australia has been involved in early discussions to build an Asia-Pacific economic cooperation body. It is unclear where these discussions will eventually lead, and if the overall opportunities for expansion of our primary commodities would in fact be enhanced by the formation of such a bloc. An Asia-Pacific trade bloc or economic cooperation body may well run counter to Australia's overall long-term interests by hampering multilateral trade liberalisation and restricting global trade. It may be better for the Government to generally encourage business to get out into the market place, the Asia-Pacific region in particular.

Australia has expanded its trade in the Australasian region by establishing a Closer Economics Relations agreement with New Zealand in 1983. The CER agreement was reviewed in 1988 and as a result, the establishment of a full free trade agreement between Australia and New Zealand will be accelerated to 1 July 1990, five years ahead of the original timetable. Two-way trade with New Zealand rose to $3.9 billion in 1987-88, an increase of almost 22 per cent on trade for 1986-87. Since 1983, trans-Tasman trade has increased by $1.9 billion, including a modest increase in agriculture, forestry and fisheries of $397 million. Australia's opportunities for trade and scientific collaboration with New Zealand are expected to increase following the establishment of the full free trade agreement.

### 3.2.3 Market opportunities

The future for the growth of Australia's export of primary commodities lies in Asia. The potential for expansion of agricultural exports to Japan, as its import policies become progressively liberalised, is well known, particularly at this stage for beef. However, the size of the prospective market offered by the developing countries of Asia is enormous, especially Korea, Thailand and Taiwan. Economic growth in Asian countries has been stable and high, well above the OECD average for the period 1976 to 1986. It is estimated that the total income of
developing Asia, which currently represents about 7 per cent of world income, will account for about 25 per cent of world income in 2020 and 45 per cent in 2040. This rapid increase in income will bring about a strong expansion in demand for primary commodities, particularly for agricultural products, where these countries do not generally possess a comparative advantage. The growth in demand for food could average 4.5 per cent a year over the next forty years and the increase in demand for non-food agricultural products should be much higher.

There are several caveats to this optimistic trade outlook. The overriding consideration is the continued maintenance of political and social stability in the Asian countries. One problem is the propensity of developed countries to raise protective barriers which adversely affect demand for the manufactured exports of the developing Asian countries. Another uncertainty is that Asia’s rate of economic growth may not be sustained. A further problem is whether these countries, like many developed countries, will protect domestic agriculture as incomes rise.

Other market opportunities include the potential for increased trade with the centrally planned economies of Eastern Europe, where socio-economic change is occurring, and with the Middle East. Australia is actively pursuing these opportunities.

Other countries such as India, Argentina, Chile and Brazil offer some potential as markets, but Australia allocates little effort to developing them and furthermore, the South American countries are generally perceived as competitors in both agriculture and mining.

3.3 Internal environment

There are many domestic policies and factors which have a significant bearing on the current and future international competitiveness of the primary sector industries. The major ones are discussed below.

3.3.1 Exchange rates

A major cause of uncertainty for Australian trade is the exchange rate. The Australian dollar was floated in late 1983. A major benefit from a floating exchange rate is that it can rapidly reflect the longer term market forces in the economy, such as terms of trade, industry competitiveness and inflation, and produce accurate market signals to which producers and consumers can respond.

As well as this benefit, the exchange rate has also reacted to short-term factors such as changes in monetary policy and other factors such as market sentiment. This has caused the exchange rate to be maintained at levels which are inconsistent with its longer term sustainable level. ABARE research shows that short-term influences caused an excessive decline in the Australian exchange rate in 1985 and 1986, and to a more limited extent, excessive strength in the exchange rate in the latter part of 1988 and early 1989.

A short-term elevation of the exchange rate, which does not accurately reflect market forces in the economy, erodes export earnings and reduces international competitiveness. This is well recognised in the primary industries. For example, it has been estimated that for every rise of 1c in the value of the $A against the $US, returns to Australian farmers drop by $250 million. The following table shows the situation for the minerals industries.
Table 3.1 Export income in the Australian minerals industries as a function of exchange rate

<table>
<thead>
<tr>
<th>$A$/US (cents)</th>
<th>Australian minerals industries export income (A$ billion)</th>
</tr>
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<tbody>
<tr>
<td>70</td>
<td>23.4</td>
</tr>
<tr>
<td>80</td>
<td>17.8</td>
</tr>
<tr>
<td>90</td>
<td>15.8</td>
</tr>
</tbody>
</table>

3.3.2 Transport costs

Transport services are a critical component of export activities. Transport costs have a significant bearing on the overall competitiveness of Australian exports. They are currently excessive, not only through inefficiency and protection from international competition, but also because freight is frequently used as a source of revenue by State Governments, unrelated to the costs and efficiency of conducting the service.

Reform of Australia's transport systems is long overdue, but Government inaction on this issue has resulted in considerable additional costs to the primary sector industries and the economy as a whole.

A recent study commissioned by the Business Council of Australia estimates that the potential cost savings from transport reform are $2 billion a year in 1986-87 dollars, or 18 per cent of total transport costs.

Transport reform has to cover restrictions on competition between rail, road and coastal shipping, and barriers to competition within transport modes as well as restrictive management and work practices. The problem of excessive transport costs has been recognised by the Government and there have been several recent reports: the IAC report on coastal shipping; the Royal Commission into Grain Storage, Handling and Transport; and the Inter-State Commission's review of the waterfront. Many of the recommendations made by the Royal Commission into Grain Storage, Handling and Transport are being implemented. The Government has recently announced that it intends to implement the recommendations of the Inter-State Commission's review of the waterfront. However, implementation of recommendations on the important areas of coastal shipping, trans-Tasman shipping, and rail transport are still some way off. In the interim, the combined penalties of high costs and inefficiency remain a major impediment to the export competitiveness of the primary sector industries.

3.3.3 Restrictive management and work practices

Labour disputes over real and perceived restrictive management and work practices are a major concern. They impose unnecessary costs which can ultimately be great enough to reduce industry competitiveness. Recent protracted labour disputes in the coal and iron ore industries have impaired production and adversely affected the competitive ability of these industries in gaining export income.

Australia's record in this area has not been good and further improvements will be necessary to remove this significant impediment to industry competitiveness and foreign investment. This is now well appreciated by the ACTU.
3.3.4 Foreign investment

Australia has, and continues to suffer from, a lack of domestic capital formation. This is particularly important for the primary industries sector which is capital intensive. Lack of sufficient capital capacity is one factor which prevents Australia from optimising the potential of its resource endowments.

The current low level of domestic savings in Australia is insufficient to service the capital requirements of growth and development in the economy. The existing taxation regime, which is subject to much debate, will continue to hinder domestic capital formation because it provides little incentive to save and encourages consumption.

Foreign investment in the efficient primary industries has brought and will continue to bring with it significant benefits. These include improvements in trade performance and operational improvements such as the introduction of high level skills, new technology, more jobs, and industry diversification. Thus, there are major benefits conferred on the Australian economy, and where these benefits occur in import-replacing and export oriented industries, there is a positive effect on Australia's balance of payments. Table 3.2 shows the stock of foreign investment by industry in Australia for the years 1982 to 1987. It is evident that the mining industries have received the majority of foreign investment made in the primary sector. The agricultural industries have had comparatively little foreign investment during this time, although this increased in the last year.

Concerns are often raised that foreign investment brings the risk of vertical integration and market exploitation. This need not be an issue if policies are in place to ensure that there are no barriers to market entry. In other words, the same policies would apply when it is desired to prevent an Australian business from exploiting its suppliers or customers.

A good current example of where foreign investment may be invaluable is in the beef industry. The liberalisation of the Japanese beef market will result in an enormous opportunity for the Australian beef industry to gain market penetration, provided it is able to produce the required product – marbled beef. This will involve an increase in the number of beef cattle feedlots and domestic capital investment may not be sufficient to take full advantage of the opportunity, particularly in light of restraints imposed in Australia to new adjustment by State Meat Authorities. Another example is the foreign investment, mostly by the French and the Japanese, in value added wool processing in Australia. The processing and trading expertise of several multinational companies has significantly benefitted Australia's wool exports.

Table 3.2 Foreign investment in Australia by industry

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>$468</td>
<td>$534</td>
<td>$527</td>
<td>$590</td>
<td>$555</td>
<td>$882</td>
</tr>
<tr>
<td>Mining</td>
<td>$10 229</td>
<td>$14 642</td>
<td>$15 388</td>
<td>$19 504</td>
<td>$17 639</td>
<td>$26 991</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>$13 081</td>
<td>$15 861</td>
<td>$17 638</td>
<td>$20 933</td>
<td>$25 381</td>
<td>$32 815</td>
</tr>
<tr>
<td>Services</td>
<td>$26 697</td>
<td>$38 215</td>
<td>$45 889</td>
<td>$67 135</td>
<td>$89 859</td>
<td>$107 313</td>
</tr>
<tr>
<td>Unallocated</td>
<td>$1 850</td>
<td>$1 781</td>
<td>$2 455</td>
<td>$3 072</td>
<td>$5 164</td>
<td>$5 013</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>55 395</strong></td>
<td><strong>71 033</strong></td>
<td><strong>81 897</strong></td>
<td><strong>111 234</strong></td>
<td><strong>138 598</strong></td>
<td><strong>173 014</strong></td>
</tr>
</tbody>
</table>
4.1 Introduction

This chapter examines the trends and prospects for various industries of the primary sector, emphasising market opportunities, the role of science and technology and impediments to the success of these industries in the next ten years. It does not aim to be exhaustive and covers some of the larger as well as the smaller industries of the primary sector.

Growth opportunities for all the primary sector industries need to be maximised to ensure the full potential benefits flow to the economy. The smaller, usually high value industries should not be neglected as they are becoming increasingly important in terms of the magnitude of their contribution to the economy and their ability to exploit market niches. Equally, the impact of the larger industries should not be forgotten as a small change in growth can yield enormous benefits because of their size, well established infrastructure and confirmed export markets.

4.2 Agricultural industries

4.2.1 Wool

Recent higher, but fluctuating prices for wool have now made it, once again, Australia's single most valuable commodity export. In 1987-88, wool exports were worth $5.7 billion, accounting for 70 per cent of world apparel wool trade.

The industry is confident about the future, particularly in light of recent higher prices for greasy wool and the trend in fashion for pure wool garments. Increased competition from cotton and renewed competition from synthetic fibres can be expected in the future. Increased competition from other wool exporters is likely to come from South America, particularly Argentina, which is expanding its wool production capacity.

Australia currently exports about 75 per cent of its wool clip in unprocessed form and it has been suggested additional processing would significantly elevate wool export income.

The largest potential for adding value to Australia's wool exports lies in further early stage processing. In a recent report, EPAC suggested that the proportion of the wool clip scoured before export is expected to rise from 23 per cent in 1987-88 to 30 per cent in 1990. This does indeed appear to be occurring but would only add about $35 million to export revenue. Increased export of worsted types of wool in the form of combed top seems to offer the most potential for adding value. The recent rationalisation of global combing capacity and high rates of wool production have meant that global combing capacity utilisation is generally running at high levels. The corollary is that Australia, which can offer decentralised locations and low capital intensive systems for treatment of scouring effluent, has become an excellent investment opportunity for major early stage wool processors, who are now adopting global investment strategies.
The Australian textile manufacturing and clothing industry receives substantial levels of assistance and appears to be uncompetitive in international terms. While these assistance measures remain in place there appears to be limited scope for adding significant value to the wool clip through the export of yarns and fabrics.

In the past 30 years the wool industry has set an example in international demand building. It is now obtaining a good return on the investment in basic research and development, product and process development, and the world-wide promotion program, conducted in cooperation with the wool industry in other countries. The wool industry has a history of creating market demand for its products, as highlighted by the development of the 'cool wool' market for lightweight woollen garments. There is significant potential for further market development if research into further product development is successful. Wool textile research will be an important determinant of the market share obtained by wool products in the future. Further developments can be expected in scouring technologies, spinning technologies to produce finer fabrics, dyeing technologies and research aimed at applications of wool where moisture resistant properties are important, for example, outdoor use in wet weather.

Productivity gains can be expected through further genetic improvement of sheep. Computation of data on sheep characteristics such as fleece weight, fibre diameter and body weight through national schemes like WOOLPLAN will increasingly assist breeders and commercial producers alike.

Genetic improvement of sheep as a result of applying recombinant DNA technology is unlikely to have any major impact before the year 2000. There may, however, be indirect applications where the benefits of recombinant DNA technology can be captured. For example, in the area of pasture improvement, work is being undertaken to produce strains of subclover and lucerne possessing increased amounts of sulphur containing amino acids compared with amounts contained in existing strains. Supplying more of these type of dietary amino acids to sheep will ensure greater stimulation of wool growth.

Improvements to pasture will also come from work to reduce acid soil effects, biological control of weeds, improved control of animal and insect pests and overall management strategies.

Drug resistance in ecto- and endoparasites of sheep is a major concern and can at least be expected to be attenuated in the next decade through application of research on chemical and biological control.

With the increase in industry training efforts, the number of skilled shearers is expected to be consistent with demand in the next ten years. Considerable effort has been devoted to developing robotic and biological defleecing technologies. These are unlikely to impact on traditional shearing techniques in the next decade, despite the considerable progress which has been made.

Further progress is expected with the objective measurement system for greasy wool, leading to total 'sale by description' rather than physical appraisal by the buyer. While such a system would produce benefits in wool handling, preparation and selling, the greatest advantage will be the added precision in the use of wool as a textile fibre. Currently, the only physical appraisal is a brief look and feel of wool in the sample box. The buyer relies on objective measurement to describe the fineness, yield and impurities of the sample.
## 4.2.2 Meat and livestock

Exports of meat and live animals in 1987–88 were valued at $2.5 billion, with beef accounting for almost $2 billion.

The market potential for beef exports is considerable. Realisation of this potential depends on the continued economic growth in Asia, the continued liberalisation of beef import restrictions by Japan, and Korea’s assurance not to reintroduce an embargo on beef imports. Australian exports to the Japanese and Korean markets could increase from the current 150,000 tonnes to 1 million tonnes by the year 2000. Our current major export market for beef, the US is expected to decline in relative terms, but remain important despite continued subsidisation of US beef producers. The EC market is something of an unknown – if the beef industry were rationalised and the level of subsidised product placed on world markets were reduced, then opportunities in the EC market and other export markets would arise for Australia.

An important factor for the bright Japanese and Korean market prospects is the impact of foot and mouth disease import policy. Currently, both Japan and Korea import beef only from countries which are foot and mouth disease free. If foot and mouth disease were to become endemic in Australia, our exports of beef to these countries (and to the US) would be severely restricted. It is therefore essential that quarantine measures be maintained at a level which continues to prevent the spread of foot and mouth disease to Australia.

The expected increase in exports of specialised, higher value product for Japan, together with the swing to higher quality and value exports to markets such as South East Asia and North America, will affect the cattle industry in different ways. For example, Australia’s share of Japanese beef imports has declined in recent years because of the disproportionate growth in imports of grain fed beef, sourced mainly from the US, compared with grass fed beef. Australia has responded to this challenge by establishing more feedlots and producing greater numbers of grain fed cattle. However, a great deal of consumer research remains to be done on the Japanese market. It is quite possible that following liberalisation, and lower prices for the consumer, that Japanese consumer trends will alter to favour Australia’s traditional product, grass fed beef.

The development of brands and their promotion is emerging as a major issue for Australia to tackle as it attempts to increase its world market share of beef. The efficiency of converting livestock to meat is likely to be enhanced within the next decade by the development and implementation of automated slaughter technology, including robotic deboning of beef. The application of the concept of total quality assurance (as successfully used in the Japanese car industry) to the meat industry is being closely examined. If the system is introduced in Australia for the meat export industry, quality improvements and inspection cost reductions of the order of 30 to 50 per cent can be expected.

Productivity increases can be expected in several areas. A major program, under the auspices of the Australian Meat and Livestock Research and Development Corporation, is being conducted to improve the efficiency of production of Australia’s northern beef herds. This is a wide-ranging program covering a variety of factors of production, including the type of cattle. Recently, frozen embryos of the Boran (from Zambia) and the Tuli (from Zimbabwe) cattle have been imported and, if appropriate, will be integrated into Australia’s northern cattle herds.

A technique which could have a major impact on reproduction rates is embryo transfer, which circumvents infertility problems which are caused by fertilisation failure. In future, it is likely that embryos will be supplied from a breeding centre, as semen is today.
Further advances can be expected in cattle breeding through the continued development and extension of the BREEDPLAN scheme, a component of the National Beef Recording Scheme, launched in June 1988. The scheme is the most advanced system of genetic evaluation of cattle in the world and has attracted interest from Canada, Japan, New Zealand and the US, where BREEDPLAN projects will soon commence.

Developing new products not only for the domestic market, but also for export markets will acquire more importance. Significant progress has been made on the control of fermentation processes used to produce fermented meat products. The development of a co-extrusion process in which sausages containing meat with a layer of sauce are produced has attracted overseas interest.

Packaging techniques, particularly with the aim of extending shelf-life will receive continued attention. A very promising approach involves gas exchange technology for long-term preservation. Packages are flushed with an inert gas to reduce microbial contamination before sealing.

Improved by-product processing can be expected. Research which could revolutionise the Australian tanning industry is being supported by the AMLRDC. The project involves application of modest pressure during the tanning process which could reduce processing time from hours to minutes. The pollution problems encountered in fellmongering – the initial stage of making leather from hides and skins – are being examined.

4.2.3 Grains

In 1987-88, Australia's grain exports were worth $2.2 billion. Of this, wheat accounted for $1.7 billion. In recent years, Australia's wheat exports have declined significantly in the face of enormous stockpiles (resulting from the protectionist policies of the EC and US) and consequent depressed prices. The decline in these stockpiles, combined with adverse weather conditions for the US wheat crop mean that our wheat exports are likely to increase rapidly in the medium term.

Asian markets, especially China, offer the greatest potential for export growth of wheat. Australia is geographically well placed to service these markets. An impediment to the development of these markets is the traditional preference for grains other than wheat, especially rice. In an attempt to further develop the wheat market in China, the Australian Wheat Board has recently constructed and commissioned the China-Australian Training Bakery in Tianjin, China.

As part of the trend for manufacturers to use grain possessing qualities that match their end-use needs, overseas markets are expected increasingly to demand grain with well-defined properties. Breeding programs will be tailored to meet market requirements. Previously these programs have concentrated on agronomic qualities, disease resistance and high yield, but have generally given little attention to quality considerations relevant to the final product. Further work is required, but techniques to produce different strains of wheat with different desired crop-use qualities, compatible with high yield, are expected to be developed.

To make the best use of grain cultivars with different, well defined qualities, it is essential that they be identified quickly and accurately, in the first instance, at the silo. Currently, distinctions are made visually, but development of chemical and physical techniques are predicted, which would make it possible to segregate grain at the silo on the basis of end-use requirements.
Control of insect infestations in stored grain is vital since Australian wheat is guaranteed to all buyers to be insect-free. Resistance by stored grain insect pests to chemical protectants is a major problem. Another concern is the level of chemical protectant residues in stored grain. Recently, CSIRO has patented a controlled low flow fumigation system, using the chemical phosphine, to overcome resistance problems and minimise residue levels. Nonetheless, insects have demonstrated a remarkable ability to develop resistance to chemicals and further work on control methods will be essential in the future.

Provided it is widespread and well understood, information available to farmers on markets, via personal computers linked to major databases, will be valuable for crop management. However, it is likely that financial and management education will be a necessary preliminary to ensure maximum access and benefit from such information.

Ninety per cent of Australia's grain exports are unprocessed. A possible area of growth is in gluten exports. Gluten is the second most important processed grain export after malt and its extracts. It is hoped that research aimed at modifying the properties of gluten (the protein fraction of flour) will give it new properties so it can substitute for the more expensive food proteins used in processed products.

4.2.4 Horticulture

Australia's horticulture industries, collectively valued at close to $2 billion, have traditionally had a domestic market focus. An increased export market orientation has emerged in recent years, but there are problems. Commonly, the approach to export markets has involved too many product lines with small volumes, exacerbated by difficulties in developing uniform export standards.

For seasonally produced crops, Australia, as a southern hemisphere country, has the opportunity to further exploit its advantage of being able to supply fresh horticultural crops out of season to northern hemisphere markets.

Consumer preference for fresh, well-presented products in excellent condition, dictates the need for suitable post-harvest methods. The need for an integrated approach for handling, transport and storage techniques throughout the horticulture industries has been recognised previously. To maintain and upgrade international competitiveness, improvements in these techniques must continue.

The Australian wine industry is one of the most notable examples of an industry which has used technology to create a series of products which are internationally competitive because they are both high quality and distinctively Australian. The innovative use of mechanical harvesting and pruning, new vigorous rootstocks and a range of new grape varieties from overseas and local sources, coupled with a well-developed infrastructure and excellent marketing expertise, have facilitated the recent export focus of the industry. Further expansion of wine grape growing areas, especially in cooler regions, to meet domestic and export marketing requirements can be expected.

Australia's ability to compete with other countries in the production of dried grapes could be considerably enhanced by increased mechanisation of the production process and consequent savings in labour costs. Research to this end is in progress. A greater variety of products would also aid competitiveness. CSIRO has developed a range of new grape varieties that dry to form products that could fill market niches.
The growing and marketing of table grapes has expanded dramatically over the past five years. The use of pre-harvest and post-harvest technologies to produce the required product and transport it in good condition have permitted penetration of European markets. Similar, but as yet little exploited opportunities exist for the export of table grapes to Asian markets.

Production of citrus varieties, committed to juice production, and the development of mechanical harvesting methods could lead to the replacement of Australia's significant imports of citrus juice. Opportunities exist to grow red or pink fleshy grapefruit in our tropical and subtropical regions. These grapefruit could easily gain access to export markets, provided appropriate treatments to kill insect eggs and larvae are used.

There are bright prospects for the development of a successful cashew growing industry in northern Australia. Selection of high yielding trees and mechanisation of the growing and processing procedures are essential. Unlike the macadamia nut, cashews are quicker to come into production. As with agriculture, Australia's horticulture has been based on the development of exotic species; the potential for exploiting native species for food and medical properties has been virtually ignored. Of the diverse Australian species, only the macadamia nut has been cultivated commercially. Assessment of the food and medical potential of other species could form the basis of a wide-ranging publicly sponsored research effort.

Ornamental horticulture is expanding rapidly, with ornamentals such as Geraldton Wax, Thryptomene, Sturt Pea and Kangaroo Paw finding ready markets in the USA. However, the industry requires marketing skills, capital and a heightened research effort to achieve its considerable potential.

Native plants with medicinal properties such as the tea-tree *Melaleuca alternifolia* are farmed in small quantities. The potential for development of the product as an ingredient in cosmetic preparations and as an antiseptic are considerable, and is being explored by several small companies. The future expansion of the industry will be enhanced by improved cultivation and harvesting techniques, by the discovery of uses for distillery by-products and by the validation of tea-tree oil for new therapeutic uses.

### 4.2.5 Sugar

The sugar industry has become more streamlined, a necessary process in light of the lifting of the embargo on sugar imports. Some markets may be lost following the termination of the embargo, but gradual growth in annual exports can be expected in the medium term. In 1987-88, sugar exports were valued at $669 million.

Only marginal changes are likely to occur in milling technology. Greater production increases will result from better utilisation of capital equipment by operating seven days a week and for a longer period each year. Being a seasonal industry, maintenance costs of capital equipment are high. Implementation of findings from research into predictive maintenance is likely to result in considerable savings.

Research into plant breeding will remain important. Higher yielding canes, producing more sugar over a longer growing season, and canes resistant to disease and weather stress are all being examined. Because of long lead times the results of this work are, however, not likely to be achieved until the turn of the century.

Continued developments in disease and pest control, with an increasing emphasis on biological control can be expected.
Increases in irrigation efficiency will occur, but not on the same scale as the recent impact of laser levelling. Combined with improvements in cultural practice, harvesting performance will improve so that non-cane elements (particularly soil) are excluded during the procedure.

The by-products of sugar cane processing have the potential for further development. While ethanol is the best known by-product, sugar cane fibre is likely to receive the most attention. Ethanol production for transport fuel use is still not commercially competitive against oil-based products. Changes in milling technology will permit sugar cane fibre to be preserved for use in paper manufacture.

Advisory services, using information technology will increase. There are sufficient farmers interested in taking advantage of these services, aided by the sugar mills, to disseminate the benefits of more efficient management throughout the industry.

The most promising value-added opportunities appear to be in the export of processed products containing sugar, rather than in the export of refined sugar. Transport costs and trade distortions in the EC limit the opportunities for viable exports of refined sugar – mostly, the returns from trade in raw sugar are greater. Significant quantities of sugar are exported in products such as preserved foods, confectionary, dairy foods, alcoholic and non-alcoholic beverages, and bakery products. The increased competition following the lifting of the embargo on sugar imports should ensure that Australian processors pay similar prices for sugar as their overseas counterparts, and are not competitively disadvantaged by paying higher prices.

4.3 Minerals and energy industries

4.3.1 Iron ore

In 1987-88, Australia exported $1.8 billion of iron ore and $150 million of iron and steel.

Iron ore consumption will grow at a rate marginally below steel consumption due to continuing development of scrap based mini-mills. Australia should maintain its market share and be able to increase its share of the incremental demand in the regional area, particularly if an improved reputation for supply reliability could be achieved. Product upgrading and differentiation in processing and upgrading iron ore will reduce chemical and physical impediments using higher components in blends and reduce utilisation costs for consumers. Further focus on adding value, through agglomeration and development of new technology such as HiSmelt will aid Australia’s competitiveness.

Operational procedures of Australia’s iron ore producers are likely to change. The move to larger cost effective operating units, particularly of mobile equipment will be important. Other changes that can be expected include:

- bucket wheel excavators in mines handling softer and fragmented ore;
- conveyors for in-pit transportation as open cut mines develop; and
- further automation of product quality assessment methods to help refine grade control and blending techniques.
Australia is a world leader in developing transport for metal ores. The development of head hardened rails which dramatically reduced the rail transport maintenance costs in the Pilbara region was a major breakthrough. Incremental improvements can be expected in this area, with consequent cost benefits, including the possible electrification of the rail systems.

4.3.2 Bauxite, alumina and aluminium

Since the early 1970s, the aluminium industry has undergone very rapid growth. The value of bauxite exports has doubled, alumina exports have increased 6 fold, aluminium metal exports have increased 24 fold and semi-finished aluminium products have increased 30 fold. These increases reflect price and volume changes as well as the trend towards adding value before export. In 1987-88, alumina exports were valued at $1.7 billion and aluminium exports at $1.8 billion.

Australia is the world's lowest cost alumina producer and will expand its market share in the Asian region where consumption is expected to grow strongly. Product differentiation, through differences in chemical purity of alumina, can be expected in the next ten years and is one means of securing an increased market share. The industry has recently indicated that it plans to upgrade its alumina refineries and significantly increase refinery capacity.

The potential for growth in aluminium metal exports is considered to be strong. If existing industry plans go ahead, aluminium smelting capacity would rise by over 30 per cent. Improvements in process technologies are expected to be incremental: there are no major new breakthroughs on the horizon. The R&D supporting these improvements will become more involved in obtaining increased output from existing capital intensive upstream facilities, and concentrating more on quality and new and differentiated downstream products. It has been estimated that Australia could virtually double its aluminium exports by the year 2000, from $1.2 billion in 1987 to $2.2 billion (in 1987 dollars).

Increasing emphasis on later stage processing of aluminium before export is expected to continue. This involves the semi-fabrication of aluminium into products such as foil, extrusions, sheet and plate. Possibilities for further processing exist for production of aluminium alloy engine blocks and car wheels, and aluminium food containers. Research is continuing into new light weight aluminium-lithium alloys which offer good prospects for the development of products for export. To increase the export of semi-fabricated aluminium, marketing and packaging skills will need to be improved and production volumes will have to be increased to reduce unit costs.

4.3.3 Gold

In 1987-88, Australia exported about 80 per cent of its total gold production, generating $2.4 billion in export revenue, making gold Australia's second largest single mineral and energy export after coal.

The gold industry in Australia has undergone a remarkable turnaround during the past decade and gold has re-emerged as a major export industry. Production is expected to peak in 1990 as a result of the introduction of the gold tax in 1991. There is likely to be considerable rationalisation of the industry, and despite recent high levels of capital expenditure, particularly in large gold deposits, it seems inevitable that gold production will decline significantly.
Exploration expenditure has increased six fold over the last five years (from $96 million to $581 million) and new techniques are being used to identify targets, especially buried gold-ore bodies, for drill testing. This level of activity will need to continue as many of the current Western Australia gold mine operations (which accounted for 71 per cent of Australia's total gold production in 1987) have short economic lives.

Further advances can be expected in drilling techniques, mine automation and metallurgical technology, all of which will permit the exploitation of previously uneconomic gold bearing deposits.

Conventional recovery of gold from ore is by cyanide extraction. However, it has proven difficult to extract gold from some gold bearing ores using this process. There are good prospects for bioleaching (using bacteria) of ores not amenable to cyanide extraction. Development of technology to overcome arsenic disposal problems after the processing of arsenic-rich ores will be important to the industry's future.

The greatest potential for adding value to gold, if labour costs can be reduced, is in the production of jewellery. There is currently no formal jewellery trade in Australia, although world trade in jewellery is growing strongly. Another area is in the production of gold coins – Australia participates in a small way in this market, but the potential would not seem to be very great.

4.3.4 Base metals

Australia's exports in 1987-88 of the base metals, copper ($402 million), lead ($545 million), nickel ($530 million) and zinc ($581 million) totalled almost $2.1 billion.

Expansions to Australia's copper mines and refinery capacity, particularly at Olympic Dam and Mt Isa should significantly increase Australia's copper exports. Increased market share is confidently predicted since Australia is only a small copper producer by world standards and an increase will require little adjustment from other competitors.

Australia is the world's largest exporter of refined lead and the second largest exporter of zinc. Despite competition from alternative materials, markets for zinc and lead are expected to increase. A new smelting process, known as Isasmelt (developed jointly by CSIRO and MIM) will allow production costs to decrease while increasing productivity and productive capacity for both zinc and lead. Incremental technology improvements will facilitate treatment of relatively low grade concentrates.

Unless further exploration results in new finds, Australia's nickel producing capacity could decline, resulting in a loss of world nickel markets.

4.3.5 Mineral sands

Australia is the world's largest producer and exporter of mineral sands, accounting for major amounts of world production of rutile (47 per cent), zircon (59 per cent), ilmenite (23 per cent) and monazite (66 per cent). The bulk of Australia's production is exported, largely in unprocessed form. Total exports of mineral sands were $367 million in 1987-88, with ilmenite contributing $62 million, rutile $163 million and zircon $142 million.
Demand is predicted to continue to be strong for titanium dioxide pigment, which is widely used in the paint, papers and plastics industries. This pigment is produced directly from ilmenite and rutile. Ilmenite can also be processed to synthetic rutile and then converted to titanium dioxide pigment. Australian capacity for synthesis of rutile and pigment production is expected to expand, with consequent benefits for export returns. Conversion of ilmenite to synthetic rutile increases its export value almost six fold, and conversion to titanium dioxide pigment about fifty fold.

Australia does not process monazite into rare earth compounds and is the only major monazite producer not to do so. One company is adding significant value to zircon by converting it to partially stabilised zirconia. This ceramic is expected to be useful in engineering applications and development is currently slow, but could be significant by 1995. Other opportunities exist for processing, but access to suitable technology is an impediment, as it is tightly controlled by foreign interests.

There is little processing of zircon in Australia. There is potential for partial stabilised zirconia and zirconia powder production as they are in strong demand as feedstocks for advanced ceramics. This lack of processing is important as rare earth elements are the basis of phosphors, lasers, supermagnets and superconductors. These are used in the electronics industry and are of very high value. Two plants for separation of rare earth elements in Australia have been announced and could increase the value of monazite tenfold by 1995 to about $60 million.

### 4.3.6 Diamonds

The development, by CRA, of the X-ray fluorescence technique for the detection and separation of diamonds was a major factor in Australia's entry into the world diamond trade in 1983, with the commencement of alluvial production at Argyle. By volume, Australia is now the world's largest producer of diamonds. Diamond exports in 1987–88 amounted to $290 million.

The major market opportunities for Australian gem quality diamonds are in the United States and Japan. The latter is growing rapidly in the value of its purchases. There is considerable potential in the Asian region, particularly in Taiwan and Hong Kong and to a lesser extent, Korea, Thailand, Singapore and Malaysia. The demand for industrial diamonds, the major component by volume of Australia's diamond production, is strong, but faces increasing competition from synthetic diamonds.

Efforts will continue to apply various technologies to the problem of reducing the processing difficulties in the production of near-gem diamonds.

Value is added to diamonds by sorting, cutting and polishing and setting them in jewellery. Sorting machines have been specially developed to handle the large volumes of material. In Australia there is a diamond processing plant in Perth which has received world wide recognition for the quality and value of the polished diamonds it produces. Labour costs mean that this plant has concentrated on high-value gems. Value adding opportunities are being pursued in India, where Australia is helping to upgrade diamond polishing technology. The end result will be more efficient processing of Australia's diamonds leading to decreased production costs and higher demand.
4.3.7 Magnesite, magnesia and magnesium

With the discovery of the world's largest deposit of high grade cryptocrystalline magnesite in Queensland in late 1985, Australia has the opportunity to become a leading producer of magnesium based products. The world market for magnesite, magnesia based products and magnesium metal is currently $5.2 billion. Australia's involvement in the world magnesite industry has only been minor - our requirements for magnesium metal are met entirely by imports.

A magnesite processing plant is likely to be established for the Queensland magnesite deposit, following the favourable findings of a detailed feasibility study. Research into new methods of magnesia recovery offer the possibility of more efficient, lower cost recovery.

Other possible developments include the production of magnesium metal, magnesium cements and building products, and calcined magnesia for filtration purposes, such as the environmental treatment of mine and process waters contaminated with heavy metals.

The possible uses of magnesium, for example in magnesium-rare earth alloys, should not be overlooked.

4.3.8 Coal

Since 1984 Australia has been the world's largest exporter of black coal. In 1987-88 Australian coal exports were in excess of 100 million tonnes, with a value of $4.8 billion. The exports fall into two broad categories: steaming coal, burned primarily for the generation of heat energy (and converted to electricity), and coking coal, which is suitable for use in metal producing furnaces. Steaming coal exports in 1987-88 were $1.8 billion and coking coal exports were $3.0 billion.

Despite some uncertainty about coal's share in electricity generation due to factors such as expected coal and oil prices, and environmental concerns about the contribution of coal combustion to the greenhouse effect, the industry expects world steaming coal demand to double by the year 2000 and to dramatically increase over the next 20 to 50 years. This expectation is based on forecasts for electricity generation in the rapidly industrialising countries of Asia and South America. In attempting to seize a share of this predicted market, Australia will have to compete not only with traditional competitors (USA, South Africa and Poland) but with newly developing countries possessing low labour costs and good coal deposits such as Indonesia, and more importantly, China and Colombia.

In NSW alone, the industry is investing $1.6 billion over the next few years in new mine developments, which have the potential to increase coal exports by 24 million tonnes each year.

World leading expertise in research on development of coal preparation and utilisation will position the industry well to take advantage of the introduction of more efficient and environmentally much less polluting technologies for coal sourced electricity generation. These technologies, such as pressurised fluidised bed combustion, will be introduced in the near future as boiler plants around the world reach the end of their useful life.
A further technological change is the development of very clean, high density co-slurries, which in the next ten to twenty years are likely to replace heavy fuel oil power stations and industrial boilers. Liquid Natural Gas and its derivatives could also be used as a substitute for coal.

In Australia there will be a movement from open cut mining to underground mining because of the costs of removing the earth from the coal seams in open cut operations. Australia is leading the world in developing long-wall mining for underground operations, and there are still considerable gains to be made through increased automation. These gains will be necessary if Australia is to remain a low cost producer of coal and compete with the rest of the world.

4.3.9 Uranium

Australia has an estimated 50 per cent of the western world's total uranium reserves and is the sixth largest producer.

Exports of uranium were $411 million in 1987-88, compared with $87 million in 1977-78. Australia's export of uranium is determined by the Government's mine policy, which limits the export of uranium, in the form of uranium oxide (yellow cake). This policy is currently under review.

Despite conflicting forecasts, it appears that uranium demand not yet committed contracts will rise with a concomitant decline in inventory stocks. Under existing policy, Australia's uranium exports are projected to be $850 million by the year 2000.

The outcome of the Government's review on its uranium policy will be a major factor for the uranium industry's future. Uranium processing and waste disposal are important issues. There is much interest in Australia in further processing uranium before export. Uranium enrichment increases the export value of uranium by about two and a half times. Australia is a world leader in developing waste disposal methods for uranium. However, the Australian method developed for the longer term immobilisation of uranium waste, known as Synroc, has yet to be adopted by a major customer.

If world demand for uranium continues at existing or higher levels, Australia should optimise its uranium export potential, including through possible participation in stages of the nuclear fuel cycle additional to uranium mining and milling, linked to a nuclear safeguards regime.

4.3.10 Oil and gas

Australia has traditionally been a net importer of crude oil. The crude oil import deficit was reduced to about $40 million in 1985-86, but has been increasing rapidly ever since. In 1987-88 the crude oil import deficit was $450 million. Australia is facing a massive liquid fuel deficit by the year 2000. At worst, net imports of crude oil have been projected to be around $5.3 billion (in 1988 dollars) by the year 2000.
Extra production from new oil finds is an obvious means of overcoming this liquid fuel problem. However petroleum exploration expenditure has dropped sharply over the past five years (from $927 millions to $495 million) because of the combined effects of the low international price for oil and secondary taxation levels imposed by government. This situation needs to be urgently redressed. A positive tax regime for exploration activity is essential, as is a greater research effort into cataloguing Australia's prospectivity for oil. The Government is about to undertake a review of crude oil taxation. The outcome of this review will ultimately be of vital importance for Australia's transport fuel security in the year 2000.

Production of synthetic liquid fuels is another avenue for alleviating the problem. The prospects for the economic conversion of natural gas to liquid fuel in the next decade are good. California is giving serious consideration to liquid petroleum gas (LPG) as its future major transport fuel. The economic conversion of oil shale or brown coal to liquid fuel is not considered likely before about 2020.

Other research avenues include: energy efficiency and conservation; renewable energy sources such as solar power generation systems, geothermal energy and biomass conversion technology; and transport technologies. The discipline imposed during the periods of high oil prices needs to be put in place again, now, if the predicted massive liquid fuel deficit is to be contained.

Australia is a significant supplier of LPG to Japan and the South Pacific ($239 million in 1987–88) and will commence exporting liquified natural gas (LNG) to Japan later in 1989. The projected level of LNG exports is expected to be $1.8 billion in the late 1990s.

4.4 Forestry and fisheries industries

4.4.1 Forestry

In 1987–88, Australia's forest sector balance of trade deficit amounted to $1.46 billion attributed mainly to the importation of pulp and paper products. Australia exported 5 million tonnes of mainly hardwood woodchips in 1987 88 to markets principally in Japan for the production of fine writing paper.

Opportunities exist for development of domestic pulp and paper processing facilities. Manufactured paper products include pulp, newsprint, liquid packaging materials and lightweight coated papers used for magazines and other rapidly growing, and high value added, printing and writing paper sectors.

However, the limited size of our domestic markets means that manufacturers also need to look to exports to meet economies of scale and to compete on world markets. The Forest and Forest Products Industry Council's (FAFPIC's) Growth Plan has identified the potential for major downstream wood processing developments (particularly in pulp and paper processing) sufficient, FAFPIC estimates, to turn around Australia's forest sector balance of trade deficit in the next 20 to 30 years. Investment of $11 billion over the next 40 years in plantation development forms the basis of the strategy providing a secure, uniform and highly productive feedstock for new mills.
The recent withdrawal of a $1 billion proposal for a new pulpmill development in northern Tasmania, following claims of possible production of dioxin arising from the pulp bleaching process, has highlighted the need for specific State and Commonwealth environment guidelines governing the operation of pulp and paper mills in Australia. The community concern generated over this issue has also signalled to pulp and paper manufacturers the need to pursue more "environmentally friendly" pulp and paper processing methods along with more paper recycling. This is an area where research into paper pulp alternatives to timber, such as sugar cane fibre, could have a significant impact.

The FAFPIC strategy is contingent upon the maintenance of the existing commercial native (old growth) forest resource base and the continued practice of integrated harvesting, whereby pulpmills can utilise residual wood which is unsuitable for sawmills along with silvicultural residues (thinnings).

Significant increases in hardwood plantation yields have already been obtained from genetic research and improvements in plantation management. Further increases in yields can be anticipated particularly from improved genetic stock. As more plantations are established and new technologies are developed in sawmills to utilise fast growing and young timber there is the expectation that plantations will eventually replace dependence on oldgrowth native forests.

High yielding plantations require good land and rainfall. A recent rapid increase in rural land prices has followed the wool boom and plantation developers will be faced with stiff price competition for available rural land. From an investment perspective, plantations need to grow and be managed for at least 7 years (for wood pulp) and probably longer before there is any financial return on invested capital.

Import replacement opportunities also exist in the use of eucalypt and pine to produce veneers in plywood production which is currently imported and sourced from tropical rainforests. Research into the problems of cutting and gluing Australian hardwoods for plywood production is expected to yield results in the next few years.

Research is continuing to resolve drying problems (eg splitting) of eucalypt timbers to enable the processing of high value furniture grade sawn timber.

Alternative end uses of waste from saw mills are being examined. Scrimber is the major development arising from this research. It is a structural material developed by CSIRO which will compete in the sawn timber structural market. The success of this development will be determined in the next several years following the recent commissioning of a production plant in South Australia.

A vital element to the continued future of the industry is the application of strict quarantine laws to imported wood, wood products or related products. There is much concern about the damage that could be done by the importation of pests known to be a problem in overseas forests and by species which are benign in their country of origin but cause significant damage to Australian forests. For example, the bark beetle genus Dendroctonus, a native of the US, kills, each year, the equivalent of Australia's total wood production.

4.4.2 Fisheries

Exports of fisheries products in 1987-88 were $724 million, with three products (prawns, rock lobster and abalone) accounting for over 80 per cent of the value of these exports. Industry representatives have suggested that fisheries exports have the potential to reach $1 billion by the year 2000.
Australian fisheries exports currently rely heavily upon a limited number of markets - 53 per cent of fisheries exports go to Japan and 25 per cent to the US. New markets in Asia and Europe will be explored. The opportunities offered by the 1992 EC common market arrangements should be exploited. In Korea and Taiwan, both important potential markets, there are high tariff barriers which will inhibit Australian entry. GATT discussions have included the export of seafoods and there is hope that increasing liberalisation will occur in world seafood trade.

The major part of export growth in wild/catch fisheries will rely on improved handling, further processing and better marketing of already established products. Developments in refrigeration, refrigerated transport and live transport will be important to the development of export markets by lowering costs.

Data on the Australian fisheries resource is seriously deficient and this must be rectified for successful long-term management of the resources. If this does not occur the stocks of fish may be fished out, to the detriment of the ocean ecology in Australia's coastal waters and of course to export income.

There will continue to be constant developments in catch technologies and technologies affecting the efficiency of catch. Sideways Looking Airborne Radar, developed by CSIRO, may well help producers detect pelagic activity (schools of fish breaking the surface of the water) more efficiently than current spotting methods. CSIRO have a new commercial service which enables producers to obtain rapid transmission of sea surface temperature images, used in working out where the best concentrations of fish are likely to be.

Because of the limited supply of fish in Australian waters we will always have to import a certain quantity ($407 million in 1987–88). Replacement of some of the imported table fish from Australia's developing tropical water and deepwater fisheries should be examined. Better use could be made of local underutilised fisheries; the sudden rapid growth of the leatherjacket fishery provides a good example of how this can be achieved by more attention to handling and marketing.

There is scope for further processing of fisheries products, including better packaging methods and through the preparation of oven-ready meals. An example of the impact of better packaging is the more than three fold increase in price obtained by one Australian company through attention to lobster packaging for the European market. The opportunity exists for the processing of fisheries product in other uses; for example, fine chemicals. However, research into this area is only at an early stage.

An area of uncertain potential is aquaculture. It is currently estimated to be worth about $108 million. Generally, investment in this area, other than oysters (pearl and edible) is very high-risk. Salmonid farming has increased but is still relatively fragile and prawn farming is not doing more than breaking even for the most successful farmer.

Production difficulties in the industry are legion and systems used successfully in Asia are of little relevance to Australia because of different labour use and the production of different products. Even if production capacity can be achieved there are marketing problems to be overcome. The industry generally lacks marketing expertise and the world market for the high-value products of aquaculture is limited and very competitive. Nonetheless the industry does possess a number of strengths which could be built upon. These include:
• scope for tailoring production schedules to supply the off-season in the northern hemisphere;

• cool climate waters with protected bays and inlets;

• relatively uncontaminated waters; and

• a lack of diseases which have caused problems in farmed populations overseas.

Exploiting these advantages will require a medium-term research marketing and business development strategy.
Technology is a vital component of the primary sector industries. It is linked to the efficiency, productivity and competitiveness of the sector. Research and development (R&D) is linked to technological development and utilisation. It also has an important part to play, directly and indirectly in the innovation process.

5.1 Research investment returns

The returns from investment in research are coming under closer scrutiny as a means of aiding the allocation process for research funds and helping to convince the private sector that there is value in investing in research. Such assessment should be both ex ante and ex post. Studies which have been completed on the returns from investment in agricultural research suggest that the rates of return for agricultural research projects range from 11 to 80 per cent, depending on the countries and projects concerned. The CSIRO Institute of Minerals, Energy and Construction recently commissioned a study on the benefit-cost ratio of eight major projects in its Division of Mineral and Process Engineering. The average quantified benefit-cost ratio across all the projects was 2.7 (a project is considered worthwhile if the benefit-cost ratio exceeds unity). There have been no similar benefit-cost analyses of the fishing, forestry, soil, water or energy R&D programs funded by the Government.

5.2 Funding and performance of research and development

Figure 5.1 shows that for 1986-87, a total of $841 million was spent on R&D activity in the primary sector. The Commonwealth and State governments provided 77 per cent of the funds for this R&D and business most of the remainder. Most of the R&D (65 per cent) was performed in the agricultural sector, followed by the minerals and energy sector (35 per cent). Table 5.1 indicates that the real annual growth rate in R&D expenditure has increased by more than 3 per cent for the agricultural, forestry, fishing and mining industries, but has declined by almost 2 per cent for the energy industries. By comparison, R&D expenditure in the manufacturing sector, which has been the subject of a concerted Government expansion policy in the last few years, has recorded a real annual growth rate of 17.5 per cent and total expenditure on manufacturing R&D is now greater than that for the primary sector. The main conclusion to be drawn from these statistics is that although recent Government policy has emphasised support of manufacturing R&D, the primary sector industries, apart from the energy industries, have maintained a positive real rate of R&D expenditure growth.

Initially the statistics on the funding of R&D in the primary sector suggest that the private sector is not pulling its weight and should contribute more. This initial impression is not correct for several reasons. Firstly, the statistics in Table 5.1 are for performance of R&D and do not show the funds, sourced from industry, which are used by the government and higher education sectors to perform R&D. For example, the industry levies which, dollar for dollar with government funds, provide the Rural Industry Research Funds are not shown, nor is the levy on the coal industry which forms the basis of the Coal Research Trust Account, administered by the Government. Secondly, the official statistics do not capture a significant amount of the R&D performed by the private sector. For the agricultural sector the survey methodology used by the Australian Bureau of Statistics for recording
Figure 5.1: Primary Sector Research and Development, 1986-87

Source of funds

- Business: 22%
- Commonwealth: 29%
- Other (a): 48%
- State: 1%

(a) Includes private non-profit

Industries in which R&D Performed

- Agriculture: 55%
- Energy: 10%
- Forestry & Fishir: 16%
- Mining: 19%

Total 1986-87 funds: $841 million
Table 5.1 Research expenditure for the primary and manufacturing sector ($ million, constant 1984–85 dollars)

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<td>1462.3</td>
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of Statistics for recording private sector R&D is inappropriate. Examples of private sector R&D not recorded include nutrient testing by fertiliser companies; development activities by scientist employees of agricultural and veterinary chemical companies; many on-farm activities of farmers and commercially funded studies done by consultants. The exploration activity and the product and equipment improvement in the minerals and energy sectors is currently not recorded as R&D activity. A good case can be made for treating expenditure on mineral and petroleum exploration, and mine and process development as R&D expenditure. Conceptually the forms of expenditure are similar: long-term, high risk activity, underpinning a great deal of development with no guarantee of return. Like R&D, exploration proceeds by a series of experiments, using highly sophisticated science and technology to create the case for each experiment and then to run the experiment. Successful exploration is essential for the survival of
the mining industries, and in that sense equates with R&D in any other industry. Expenditure on mineral and petroleum exploration and mining development would be classified as R&D expenditure, then the private sector would be seen as making much greater contribution to R&D, and companies could also take advantage of the provisions of the tax incentive for 150 per cent deductibility of R&D expenditure. Furthermore the amount of R&D attributed to industry would increase dramatically - in 1987-88, total private exploration expenditure was $1.3 billion.

5.3 Research and development mix

The question of the balance between basic and applied research in agriculture has attracted recent attention, not only from the performers of the research, as would be expected, but also from the beneficiaries of the research. If the Rural Industries Research Funds (RIRFs) are able to provide continuing support for science oriented work then Australian agricultural research will be in good position to provide strong returns for the investment. Research will continue to be well attuned to the needs of industry.

There is a widespread concern, however, that as a result of recent composition and administrative changes, the RIRFs are tending to focus more on the immediate applied, or technology-oriented research at the expense of work required to attack problems with a longer timescale, to identify the underlying factors involved in those problems, and to devise ways to solve them. Furthermore, because the rate of CSIRO's appropriation to external earnings has changed, with a greater emphasis on external earnings, equipment replacement has become an issue. This is because the RIRFs form the major part of external earnings for CSIRO and do not include the grant component for equipment.

The interdependence of basic and applied research is in danger of being overlooked. If applied research is funded at a greater rate, it will inevitably create a demand for basic research input which will either be met by the 'applied' researchers themselves or, hopefully, by an enlightened research funding agency. Similarly, basic research, rather than an end in itself, can be one of the sources of inspiration for applied or technology oriented research, and needs to be recognised as such by funding agencies.

The problem from a university perspective is that a diversion of resources towards applied research may mean a diversion of resources away from universities. The ability of agricultural and veterinary departments to acquire funding from the more usual institutional sources to make up for this loss is questionable. Therefore, the training of rural researchers (at the Masters and PhD level), in terms of numbers and breadth of the skills they acquire, is likely to diminish in future, unless specific actions are taken, particularly by the RIRFs.

It is already evident that some research students are having to leave Australia to find support for their research training.

5.4 Research status

In the minerals and energy industries a particular area of concern is the state of geology research in Australia. Earth sciences research is fragmented, spread thinly and lacks a logical national framework for its conduct. It is conducted in several CSIRO divisions, the Bureau of Mineral Resources, State Departments of Mines, sixteen universities, and potentially in another dozen or so CAEs.
The Bureau of Mineral Resources has recently been reviewed, and geological survey has been stressed as its main role. The review recommends that geoscientific maps and data and analyses should be supported where appropriate by related research. A formal framework of collaboration and cooperation with State Geological Surveys should be established, along with joint projects and staff exchanges with CSIRO, State Government agencies, industry and tertiary education institutions.

The review notes that industry groups in particular are concerned that the maintenance of the national geoscience knowledge base is not sufficiently directed at or keeping pace with user needs. Its development is hampered by insufficient collaboration between the various arms of geoscience, and access to the knowledge base is hindered by its fragmentary organisation.

The development of a comprehensive, integrated geoscience knowledge base is a fundamental national need in geoscience as a basis for exploration by petroleum and minerals industries; for the understanding and management of soil and water resources; as an input to decision making and policy formulation in resource management and related aspects of land use planning and public welfare.

The review goes on to note that the roles of BMR and CSIRO in minerals exploration techniques and ore genesis research converged during the 1970s, resulting in some disagreement over their respective areas of responsibility. More recently, CSIRO has moved into tactical applied research in direct support of industry, while BMR maintains a longer term focus. As BMR focuses its research, a gap will potentially develop in strategic geoscience research.

CSIRO's mineralogy work had the potential to become interesting research, but has not lived up to its promise. Like a good deal of geological research, it lacked the stimulation of clearly challenging problems and tended to be rather aimless. The mineral physics and remote sensing research has been better directed and the results have been of a higher standard.

Only five or six Australian university departments are consistently conducting research at an international standard. There is a widespread view in the mining industry that the number of geology departments in higher education institutions could beneficially be reduced by half or even more. An efficient approach would be for one institution in each State to be selected as the research university for the earth sciences, and funded to concentrate on research, and teaching at the honours and postgraduate level. Undergraduate teaching would occur at the research universities and at a few other institutions in each State.

5.5 Research and development organisation

The Government arrangements for the organisation of primary sector R&D are currently under review. Efficient, flexible involvement in pre-competitive research (research where the results cannot be appropriated by an individual company, but which has general value for an industry) by both industry and Government is essential. The agricultural model (the Rural Industry R&D Corporation model), while not without its problems, has been successful in funding industry-wide pre-competitive research. This model could well be applied to industries outside the rural industries. For example, pre-competitive research in the aluminium smelting, mineral sands or pulp mill industries could prove of great value in establishing technological leadership for Australian industry in these fields. However, application of the agricultural model to these industries could prove difficult as they are dominated by a small number of companies.
smelting, mineral sands or pulp mill industries could prove of great value in establishing technological leadership for Australian industry in these fields. It has been argued that application of the agricultural model to these industries could prove difficult as they are dominated by a small number of companies. It is noted though that some rural industries with Research Councils are dominated by a few large companies (e.g., chicken meat) and overseas pre-competitive research consortia of major companies have been formed, originally in Japan but now in the electronics area in the United States (Sematech) and in Europe (JESSI).

The development of the concept of multidisciplinary research centres to improve the effectiveness of primary sector research warrants more attention than it has received in the past. The development of such centres could use the Engineering Research Centres in the US as a model. Key factors include:

- quality of the research idea underlying the proposal, especially in terms of its potential for major breakthroughs, in either an intellectual or a technological sense;
- the problems being addressed should be large enough to enable a cross-disciplinary research team to work on it together and make a major contribution that could not otherwise be made; the proposal must not be a mere collection of unrelated research projects;
- the competence of the Centre director and key participants;
- industry support, and the nature of interaction with industry;
- the extent to which the Centres should improve both graduate and undergraduate education; and
- the institutional environment and arrangements; support by the university and barriers to cross-disciplinary research.

The key centres for teaching and research and more so the special research centres, administered by the Department of Employment, Education and Training, are important steps towards the eventual establishment of multidisciplinary research centres of the type exemplified by the Engineering Research Centres. Existing sites where there is a concentration of research activity, interaction with industry, but no formal focus should be considered as potential candidates for development into multidisciplinary research centres. For example, the co-location of the Waite Institute of Agriculture (part of the University of Adelaide) with a major part of the CSIRO Division of Soils, the CSIRO Division of Horticulture, a small part of the CSIRO Division of Water Resources and the Australian Institute of Wine Research, offers the possibility of multidisciplinary research centre development.
6.1 Introduction

In the past, Australia has been able to reap significant financial and social rewards from the comparative advantage embodied in its primary sector, particularly from the agricultural and minerals and energy industries. As a participant in today's global economy, Australia is faced with competitive realities which dictate a change from past practices which were sufficient for a much less competitive environment. The ability to respond to change is an historical characteristic of the primary sector which will hold it in good stead for the future. Provided the sector is able to respond with sufficient speed to changed national and international circumstances, the future appears to be sound.

ASTEC believes that primary sector products will continue to be essential income earners for the Australian economy. The mix between unprocessed and processed products is likely to change in the next ten years as further opportunities arise from the closer integration of manufacturing and service sector activities with the agricultural and minerals and energy industries. There will be an increasing role played by the smaller, high value primary sector industries in the next ten years, but the contribution to the economy by the larger industries such as wool, wheat, meat, coal, alumina and aluminium, and iron ore, will remain as the backbone of the sector.

Key issues facing the industries of the primary sector in the next decade are:

- international trading environment;
- environmental management and development;
- industry competitiveness;
- further processing of raw materials; and
- energy revenues.

These issues will have to be tackled and they are discussed below.

6.2 International trade

Liberalisation of the distorted and fragmented trade environment for primary commodities is necessary for trade in these commodities to expand to its full potential and achieve stability over the longer term. The Australian Government will have to continue its efforts in international forums, particularly GATT, aimed at achieving the objective of liberalisation. Continuation of the ABARE program of individual country studies, which direct attention to the economic and social costs of protectionist policies, will be important.

If the current round of GATT negotiations are unsuccessful in bringing about liberalisation of world primary commodity trade, Australia is likely to face an environment of increased instability in commodity prices and heightened trade tensions.
Concurrently, Australia will have to pursue export opportunities through bilateral arrangements which accord with the principles of free trade, and actively participate in any discussions to develop an Asia-Pacific trading bloc.

The major growth market for primary products is in Asia and Australia needs to be positioning itself now to take advantage of the opportunities. The Government can aid this process by increasing its formal trade presence in the countries of the Asian region and by generally encouraging business to participate in the Asian market.

6.3 Environmental management and development

The natural resources that form the Australian environment are being subjected to increased competition for their use. The uses vary and are frequently mutually exclusive. They include industrial development, tourism, recreation and conservation of the environment.

There is a clear need for the development of an efficient and equitable set of well defined procedures to determine the optimum use of natural resources, especially in light of the recent escalation of disputes over the use of community resources. At the Federal level the Government has established a Resource Assessment Commission (RAC) to make recommendations, on a scientific basis, on future resource use issues referred to it by the Government. The policy principles which form the basis of RAC considerations for resolving conflicting resource use issues are applicable to all three tiers of government decision making affecting the primary sector. They comprise:

1. There should be an integrated approach to conservation and development by taking both conservation and development aspects into account at an early stage.

2. Resource use decisions should seek to optimise the net benefits to the community from the nation's resources, having regard to efficiency of resource use, environmental considerations and an equitable distribution of the return of resources.

3. Commonwealth decisions, policies and management regimes may provide for additional uses that are compatible with the primary purpose values of the area, recognising that in some cases both conservation and development interests can be accommodated concurrently or sequentially, and, in other cases, choices must be made between alternative uses or combinations of uses.

In the fields of minerals and energy within the primary sector, broadscale industry developments involving land access and issues have been the subject of major public controversies. In some areas of Australia, however, the predicted trend in minerals and energy activities is away from broadscale operations towards underground mining. The consequent reduction in the extent of the environmental impact may reduce the number of land use disputes in the future. The economic well being of the agricultural industries within the primary sector is linked strongly with the state of the natural resources on which they are based. Australia's agricultural regions are characterised by low and variable rainfall, and highly weathered, low nutrient holding soils. The majority of soils are of intrinsic low fertility, have very
low contents of essential plant nutrients and have low organic matter contents. Australian soils have been degraded by white settlement and clearing for agriculture, but many may now be in a less severely degraded form than they were either at the turn of century (before the widespread use of phosphatic fertilisers) or in the pre-war era before the use of legume-based pastures. There are four main types of land degradation in Australia: soil acidification under improved pastures; soil salinisation, in both dry land and irrigated areas associated with overclearing; loss of soil structure; and physical loss of soil from erosion.

The total cost of agricultural production forgone as a result of land degradation is currently estimated at about $600 million each year. Most farmers are aware of the problem and are attempting to or have taken ameliorative action. To facilitate this the Government will need to consider providing incentives to farmers for land management during times of adverse climatic conditions as there will be insufficient money to invest in land improvement.

The science and technology most heavily used to document and ameliorate the problems which militate against sustainable agricultural systems relies mainly on traditional techniques of diagnosis, but is significantly under-resourced in areas of soil science and soil survey, plant genetic evaluation, ecology and economic botany. The Government has taken some steps to help alleviate the situation:

- establishment of a National Resource Information Centre to access and present available knowledge on Australia's natural resources;
- expansion and redirection of the National Soil Conservation Program; and
- establishment of a Natural Resources R&D Corporation.

The concept of environmentally sustainable development applies equally to the forestry and fisheries industries. Both of these areas are severely lacking in detailed documentation of their resources - a prerequisite for efficient long-term management on a sustainable basis. The Government has recently provided $2.9 million for the development of a National Forest Inventory.

A major factor affecting the way in which our natural resources are managed and developed is the climate. Considerable scientific, and more recently, political effort has been devoted to consideration of the greenhouse effect and depletion of the ozone layer. Awareness of the possible impacts resulting from these climatic changes is important, particularly for the agricultural and forestry industries. However, it is unclear if there is a greenhouse effect or if we are witnessing a natural climate variation (as global temperatures increase), which will ultimately be self-regulated. Further, climate models are currently not sophisticated enough to permit more than Southern or Northern hemisphere predictions of climate changes. At the regional level, it has only been possible to develop scenarios of climate change rather than reasonable predictions. Finally, the changes would appear to be beyond the year 2000. Nonetheless, a close watching brief on developments in greenhouse and ozone layer research should be maintained by all members of the scientific community in the next ten years.
6.4 Industry competitiveness

The competitiveness of Australia's industries, domestically and internationally is determined by many factors, interacting in complex ways. The more important ones for the primary industries are; productivity and efficiency (including research and development); innovative products and processes; and skills formation. These are discussed below.

6.4.1 Productivity and efficiency

The primary sector is characterised by significant productivity increases over time which have permitted it to offset the long-term deterioration in its terms of trade. Increased productivity and efficiency is essential for the successful future of the primary sector, especially against a background of increased competitive pressures. The Australian Bureau of Agricultural and Resource Economics has estimated annual productivity growth at 2.8% over the last twenty years, considerably higher than productivity growth in the economy as a whole which was 1.1%.

Technological advance was recognised as a significant contributor to productivity growth. Many non-scientific and technological factors also impact on productivity and efficiency. These include inefficient and costly transport and handling services, and restrictive management and work practices. The Government will have to closely follow up and implement the recommendations of the recent reports on Australia’s transport system, particularly in the areas of coastal shipping, rail and the waterside. Lack of progress in this area will continue to severely impair the competitiveness of the primary sector industries.

The research infrastructure for the primary sector is generally strong, particularly for the agricultural industries where there is a history of world-class research and well-developed extension activities. While very few studies have been done those that demonstrate that the returns from investment in primary sector R&D are considerable. Current levels of public support for primary sector R&D will need to be maintained in the longer term. Greater contributions from the users of this research need to be encouraged.

Several factors need to be included in any consideration of the arrangements for R&D and its future direction. These factors include:

- Attention to the balance of R&D being funded. There is concern that recent compositional and administrative changes in public funding for primary sector R&D are tending to focus more on the immediate, applied or technology oriented research at the expense of work required to attack problems with a longer time-scale. The interdependence of basic R&D is in danger of being overlooked.

- Application of the Government’s agricultural model for pre-competitive research to industries outside the rural industries, such as in the aluminium smelting, mineral sands and pulp mill industries. This could prove of great value in establishing technological leadership for Australian industry in these fields.

- Examination of the concept of multidisciplinary research centres, along the lines of the US Engineering Research Centres, to improve the effectiveness of agricultural research by making better use of existing resources.
Even if a biotechnology application is successfully researched there is the problem of commercialisation. The application has to be field tested, conform with Government regulations (although this is not currently seen as a problem in Australia), and be produced competitively on a commercial scale. All this has to be done against a background in Australia where the stockmarket is depressed and demand from investors is for high-performing, quick return stocks, and where there are very few indigenous companies which have sufficient cash flow and capitalisation to successfully bring a biotechnology application to the market place.

Information technology has enormous potential for increasing agricultural productivity, notably in the area of marketing and management systems.

There is no shortage of information systems available to aid in the management of agricultural systems. However, there is a need for the information available to be specifically tailored to the needs of the users. An excellent example of this, for intensive agriculture, is the SIRATAC system designed to assist cotton growers to control insect pests. Work is continuing on SIRAGCROP which has been developed by CSIRO and the NSW Department of Agriculture to provide farmers with information on irrigation scheduling, fertilizer and soil management, disease and weed control, and choice of cultivar. Despite the development of information systems, the incidence of on-farm computer assisted management systems is no greater than in any other small business, and is often less. Traditionally, farmers who necessarily have to take a long-term perspective, have been cautious in adopting new technology. So it may well be closer to the turn of the century before the benefits of computer assisted management systems are achieved.

Some success has been achieved in the application of electronic marketing for agricultural products. This was first done for wool where visual appraisal at market has been largely replaced by objective measurement. It seems likely that computer based livestock marketing systems such as the Computer Aided Livestock Marketing (CALM) system will replace the more expensive livestock auction sales. These systems have a further advantage in their ability to precisely specify the product – knowledge which the producer can in turn use to increase the efficiency of production by producing a product which closely matches the market requirements.

In the minerals and energy industries there will be considerable development in the area of automation and process control over the next ten years, with the aim of increasing productivity. Australia is at the forefront of technology for process control and will need to maintain its research effort to stay there. Work on the onstream analysis of base metals, bulk analysis of industrial metals and onstream analysis of coal ash is likely to yield significant results. Application of robotics to increase the automation of mining is being closely examined. The trend to deep underground mines increases the danger for miners and one way to reduce this problem and at the same time increase the efficiency of the mining operation is to use robotics.

6.4.2 Innovative primary products and processes

In an increasingly competitive environment, where consumers are becoming more discriminating, innovative products and processes can often lead to a competitive edge. An innovative product may be more competitive because it matches market requirements more closely than similar competing products, in its own right or on a cost competitive basis, or the product creates a new market opportunity because it shifts demand from other products in the market. Innovative processes can result in products being more competitive because the process may result in consistently higher quality products; it may reduce the cost of production, or it may lead to products which match market requirements.
While innovative products and processes may create a competitive edge by improving the marketability of products in various ways, that competitive edge must be translated into increased market share. Australia has an indifferent record in the overseas marketing of its products, although this is beginning to change.

It is generally recognised that there is a need for a coordinated approach to the marketing of Australian products. Too often Australian producers have competed against each other, to their mutual disadvantage, in export markets. The advantages in readily identifiable Australian products in overseas markets and the joint export marketing effort by Australian producers are obvious. The Government can continue to encourage this process through the activities of AUSTRADE.

The marketing of Australia's agricultural products is receiving quite a deal of attention from the Government. The Primary and Allied Industries Council commissioned a study on the adequacy of the existing organisation and infrastructure of Australian agricultural marketing, including the activities of the statutory marketing authorities and cooperatives, to adjust to international developments in agribusiness. This study has been recently released. The reforms being put in place to put statutory marketing authorities on a more commercial footing, so that their efficiency and capacity to respond to emerging market opportunities is improved, should continue. The suitability of these reforms should be monitored and reviewed at regular intervals to ensure that market opportunities are not lost.

To achieve its maximum potential the primary industries need to find market niches for specialised products which add value to raw products. For the agricultural, forestry and fisheries industries, the Government has implemented the Innovative Agricultural Marketing Program (IAMP). The IAMP is important because it can help the many small businesses which have a promising product, bring it to the market place. Further benefits can accrue to existing businesses which are not marketing their product efficiently. Some of the successes of the program include the demonstration of cheaper transport methods for avocados to Europe and oranges to Singapore, the development of technology for the production of concentrates from tropical fruits, and the development and test-marketing of a reconstituted sheep meat product in Japan. This program should be continued beyond 1991, when it is due to finish.

The potential for innovative product development is especially strong in the horticultural industry. Many horticultural products are produced 'out of season' to northern hemisphere markets and can therefore be sold to those markets. To achieve this potential, Australia will have to compete against other southern hemisphere producers, such as South Africa and Chile, and will have to provide a greater variety of produce to gain market share.

Another area of potential, which is receiving increasing attention is the development and export of Australia's indigenous flora. Already several farms and nurseries have been established in South Australia, Queensland and the Northern Territory, with the aim of developing orchards of green plums, the native peach or quandong, rainforest nuts and nuts related to the macadamia.

Competitive demand pressures resulting from less intense usage, through substitution and through new approaches to functional design, frequently stimulate the development of innovative products and processes. In the minerals industries these pressures have stimulated increased research into new end uses for metals and creating, in effect, a new range of mineral and metal materials with improved properties. For example, Comalco has developed an important aluminium alloy called 3MA, with exceptional hardness and wear resistance, but with good
machining properties. It offers great potential in the automobile industry, especially in engine components where the combination of weight saving and wear resistance is critical. In the agricultural industries a good example of a process innovation is the development of Sirospun. In response to the threat from alternative synthetic fibres, wool researchers made several developments, including sirospun, which is a spinning technique able to produce a weavable worsted yarn in a single stage at a 40 per cent saving over conventional processes.

6.4.3 Skills formation

The primary sector, like all sectors of the economy requires a strong and vigorous skills base as a prerequisite to utilising technology and optimising competitiveness.

Compared with five years ago, the number of students enrolling for university agricultural courses is down by 25 per cent, while the pass-mark for entry into university science courses is lower than for any other major faculty, averaging 25 scaled marks less than in Arts, and 75 less than in Engineering across all Australian universities. The perceptions of academic representatives interviewed by the working party are that scientific personnel are being lost in the disciplines of soil science, botany, agronomy and ecology. This information, together with the significant lead times for training suggests that there may be skills shortages in the agricultural industries by the year 2000.

Any skills shortage in those scientific disciplines which support research into the problems of land degradation is a major concern, and should be addressed in the Government's education policy in a similar manner to the problem of shortages in trained computer scientists and engineers.

6.5 Further processing of raw materials

Adding value to raw materials can be done in many ways, including differentiation through design, quality, handling, packaging, presentation, storage, description, promotion, distribution and further processing. Of these methods for adding value, further processing generally offers the most potential for maximising the value.

The question of the scope for further processing of primary products is an interesting one, which has generated a lot of attention in recent years. The main reason for this is that Australian exports of primary commodities are largely unprocessed and where they are processed, the processing is frequently only early stage and does not add a great deal of value. Most of the value adding through downstream processing is done by the importing countries. There is considerable potential for Australia to add the value here before export, the question is, is it profitable?

While Australia enjoys a comparative advantage in the production of many primary products, the important question is whether that comparative advantage carries through into processed products. This depends on the relative abundance in Australia of those resources needed to carry out processing activities, and whether there is any advantage in locating processing facilities close to the source of supply of unprocessed resources rather than the end-users of the processed resources. Furthermore, the industries undertaking processing must be internationally competitive to ensure the successful marketing of the processed products.
Increased processing often brings with it the problem of waste disposal, at least in the early stages where most basic processing activity involves a reduction in volume and/or weight of the raw material. Thus there may be environmental costs which determine the location of the early stage processing facilities. Indeed, these environmental costs may be judged too high to permit early stage processing to go ahead. In Australia, considerable work remains to be done to clarify environmental regulations for early stage processing facilities. This lack of certainty was one of the reasons for the proposed Wesley Vale pulp mill not proceeding.

Even if the benefits of value-adding are sufficient to justify investment, reduced market access (due to formal and informal market barriers and increased competition) may offset these benefits.

Pressure for increased processing is likely to mount in the future, in light of the possible benefits. The benefits of increased processing of primary products in Australia are variable and a decision to pursue further processing must be examined, in detail, on a product by product basis. As well as this, there is a need to link the marketing and financial skills of our service sector to the comparative advantage of our processing industries.

There are many areas of potential for increased processing, and an EPAC study lists a number of raw material processing projects currently planned or under construction which involve investment of about $3.5 billion. These projects cover the range of primary products and include food, wool, wood, gas, coal, aluminium and mineral sands processing.

AUSTRADE has conducted a detailed study on an export development strategy for the processed foods industry. It sees this industry as having the potential to be the vehicle to pursue increased exports of value-added products which will be very important in Australia's achieving a significant and sustained increase in export performance. To accomplish this several problems will have to be overcome, including the industry's fragmentation, domestic market focus, lack of international marketing expertise and lack of involvement in the development of new and competitive processing technologies.

The processing potential of the minerals sector was recently studied by the Basic Metals Industry Council. The Council concluded that there is significant potential for further processing in the bauxite/alumina/aluminium industry as well as in the manganese, mineral sands, raw earths and gemstone industries. Moderate processing potential was identified for the base metals (iron, nickel, copper, zinc and lead). The Council identified a number of constraints to the achievement of this processing potential. The constraints included the size, development and condition of the market, capital costs, overall costs outweighing the benefits, environmental costs, and access to technology controlled by overseas interests.

An emerging issue associated with increased processing is the opportunities for offshore investment by Australian businesses. If increased processing of a raw material cannot be profitably accomplished in Australia, there may be opportunities for Australia to participate in processing of the raw material in the importing country. The benefits of such investments are generally not as great as those benefits (including employment) which would have occurred had the activity been undertaken in Australia, but are still worth while to the economy provided the profits are repatriated. Such opportunities should be vigorously pursued by industry and encouraged by the Government.
6.6 Energy revenues

Energy will play an important role in the restructuring of the Australian economy over the next decade and into the next century. ABARE predictions are that by the year 2000, increases in coal, gas and uranium exports will be sufficient to offset the increases in imports of crude oil, condensate and petroleum products giving Australia a strongly positive net energy balance. This scenario warrants close scrutiny.

Australia's demand for oil is increasing and domestic production is falling. Consequently, Australia's self-sufficiency in crude oil in the year 2000 is projected to fall from the current level of 85 per cent to about 28 per cent. The net import bill for crude oil, liquefied petroleum gas and refined products in the year 2000 is forecast to be $5.3 billion. This import bill represents a substantial drain on the economy which should be examined in its own right, even though current projections indicate that it will be more than offset by export income from other energy commodities.

To reap the optimum economic benefit from the petroleum industry, the environment for exploration and development activity of the industry needs to be closely assessed, particularly the secondary tax regime. Current exploration activity has increased from the very low levels of 1987, but a large proportion of this activity is taking place in other countries. If this lack of indigenous exploration activity continues then the prospects for further finds of oil are not good.

An important factor in the net energy balance scenario for the year 2000 is the international price of crude oil. If, for whatever reason, the price of crude oil were to escalate, the net energy balance could be placed in jeopardy.

A further factor is the environment. Australia's exports of gas, coal and petroleum products could be adversely affected by the need to reduce world carbon dioxide and sulphur dioxide emissions.

Increased pressure is likely to be brought to bear on Australia's currently restrictive uranium policy. Uranium is the only mineral or energy commodity for which there are export restrictions. The increased pressure for change will come from the perception that uranium has the potential to replace polluting fossil fuels, contribute to increased export income through increased sales of yellow cake, and through sales of uranium which has been processed beyond the yellow cake stage. The Government is still reviewing its uranium policy.
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7. Commonwealth Department of Primary Industries and Energy estimate.


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"With respect to the primary sector:

Objective: To determine the contribution that science and technology could make to Australia's balance of payments to the Year 2000.

Sub-objectives: To identify those areas of the economy with the greatest potential for growth;

To determine the scientific and technological advances that could maximise Australia's export and import replacement performance in both existing industries and possible new industries, taking into account international trends in technological development and industrial competitiveness;

To identify likely barriers to production growth or export performance, and the role that technological change might play in reducing these barriers; and

To provide advice to Government on the policies most likely to maximise the contribution of science and technology to Australia's economic growth and export performance."
WORKING PARTY ACTIVITIES

In accordance with ASTEC's usual procedures a Working Party was appointed to execute the study. The Working Party comprised the following Council members:

Mr F M Davidson (Convenor)
Mr L S Zampatti
Dr L A Brodribb
together with:

Mr N Jackson Executive Director
Muswellbrook Energy & Minerals Ltd

Mr B N Kelman Director
O'Connell Street Associates Pty Ltd

Mr D B Trebeck Principal Consultant
ACIL Australia Pty Ltd

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