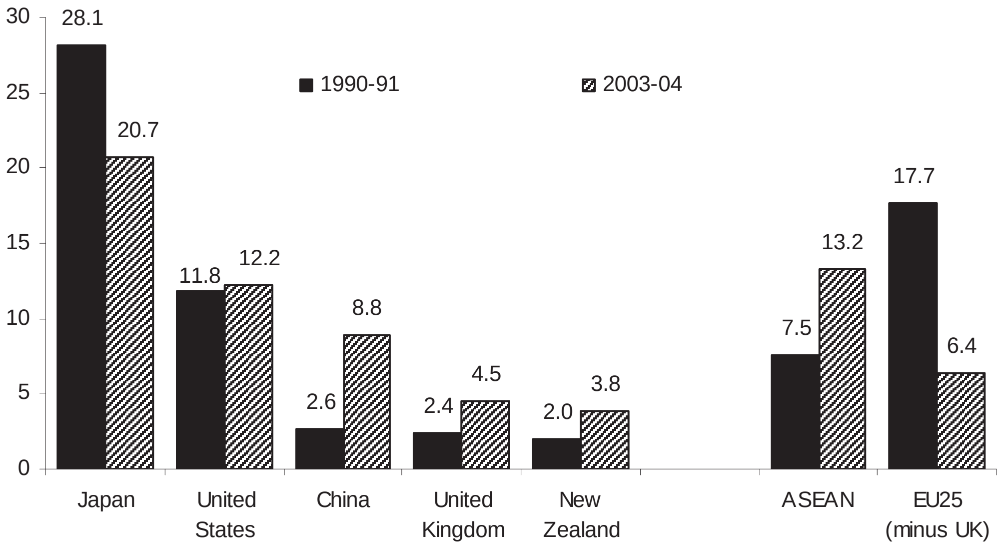
4.4 Changes in export market profile

As Australia's agricultural exports have grown the relative importance of different export markets has changed — with an increase in the relative importance of Asian markets and a commensurate decline in the importance of European markets (figure 4.13).

However, the estimates of growth in agricultural exports by country presented below are not directly comparable with the data discussed earlier as raw sugar, wheat and oats export data are unavailable due to confidentiality constraints (see ABS 2002d). Hence, the relative importance of some Asian countries, and the growth in the share of exports to South Asian and Middle Eastern destinations, is likely to be underestimated.[14]

Figure 4.13 **Australia's top export markets, 1990-91 and 2003-04[a]**
Per cent, current prices (average three years ended)



[a] *ASEAN* comprises Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand and Vietnam. *EU25* comprises Austria, Belgium/Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

Data source: DFAT (STARS Database 2005).

14 Exports of these commodities accounted for 16 per cent of total agricultural exports in 2003-04 (TREC basis). Malaysia, Korea, Japan and Canada have been key markets for Australian sugar exports in recent years while Indonesia, Egypt, Japan, Korea and Iraq have been major importers of Australian wheat (DAFF 2005)

Australia's trade in agriculture is heavily influenced by sales to three key markets — Japan, the United States and China. Combined, these markets accounted for 42 per cent of Australia's agricultural exports in the three years to 2003-04 (figure 4.13). Beyond these markets, trade in agriculture is broadly dispersed among a wide range of countries across the globe. For example, Australia's next 17 largest markets accounted for only 42 per cent of total agricultural exports.

Japan remains Australia's largest agricultural export market by a substantial margin, accounting for more than one-fifth of total agricultural exports in 2003-04. This was almost double the share of Australia's next largest market, the United States.

Slow growth in the Japanese economy for much of the period 1990-91 to 2003-04, combined with declining wool prices, saw Japanese consumption of Australian agricultural products grow at only 3.2 per cent a year in value terms. This was substantially below the rate achieved for agriculture overall (5.7 per cent) and resulted in a drop in Japan's share of Australia's agricultural exports of more than 7 percentage points. Most of these declines occurred in the early 1990s, reflecting falls in the price of wool exports to Japan together with stagnant demand. Between 1990-91 and 2003-04, exports of wool to Japan fell by more than $0.8 billion in value terms.

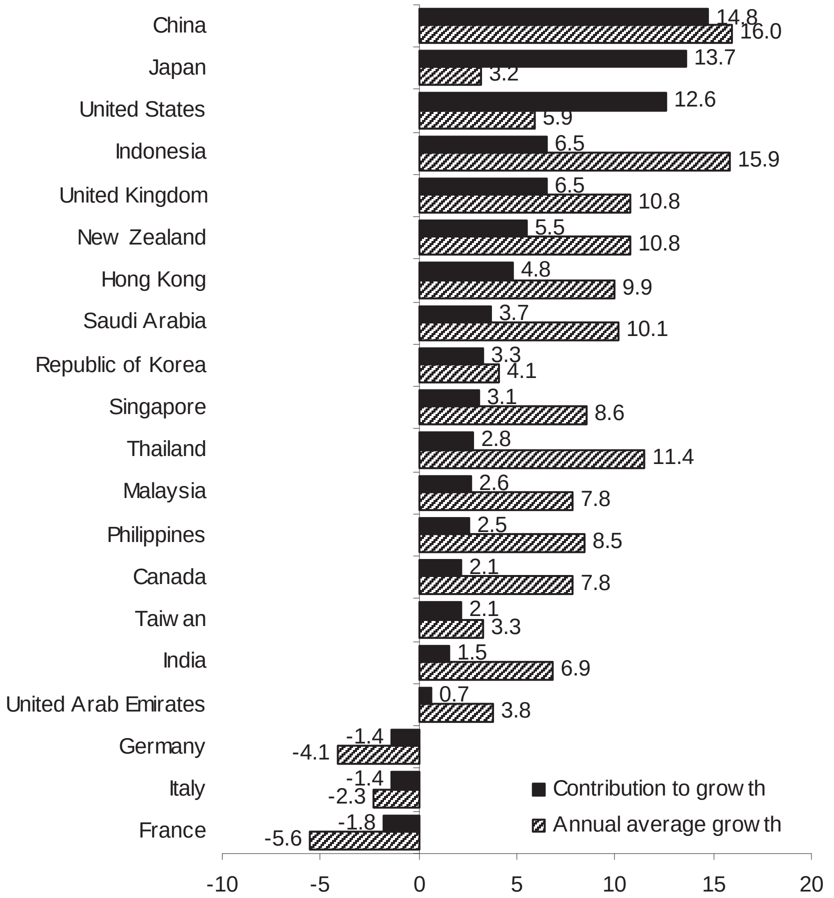
Nevertheless, the sheer size of the Japanese market meant that it still contributed a substantial 14 per cent of the growth in Australian agricultural exports over the period (figure 4.14). This growth was largely driven by increases in exports of beef and veal products, unprocessed foods, wood chips, cheese and prepared animal feeds (table 4.3).

However, the growth rate for beef and veal products to Japan is somewhat misleading as a key contributor to the growth in Australia's beef exports to Japan in 2003-04 was the positive BSE (bovine spongiform encephalopathy — 'mad cow' disease) result in the United States in December 2003 which prevented the United States from exporting to Japan. As a result, Australia's share of the Japanese beef market increased from around 45 per cent to over 90 per cent. As United States beef re-enters Japan, Australian beef exports to Japan are expected to decline — from a forecast 371 000 tonnes in 2004-05 to 315 000 tonnes in 2009-10 (ABARE 2005b).

Annual sales to Australia's next largest market, the United States, increased by almost $1.7 billion between 1990-91 and 2003-04 — accounting for 13 per cent of overall growth. This growth was almost entirely the result of strong growth in wine, beef and veal, and mutton and lamb exports (table 4.3).

Figure 4.14 **Top 20 agricultural export markets — growth rates and contributions to growth, 1990-91 to 2003-04**

Per cent, current prices (average three years ended)



Data source: DFAT (STARS Database 2005).

Despite its small initial starting share (2.6 per cent in the three years to 1990-91), China was the next largest market for Australian agricultural exports in 2003-04. The high growth rates recorded over the period saw it contribute 15 per cent of overall growth — resulting in a more than tripling in its share of total Australian agricultural exports over the period. This strong growth was driven by imports of wool, and, to a lesser extent, sheep and lamb skins, cotton and inedible beef and mutton tallow (table 4.3).

Strong growth in exports to the United Kingdom has seen it become the fourth largest importer of Australian agricultural exports — up from ninth in 1990-91. Nevertheless, it remains a small market (4.5 per cent) relative to the dominant role it played as the major external market for Australian agricultural products during most of the 20th century.

Table 4.3 Growth in major agricultural exports to Australia's top 5 markets, 1990-01 to 2003-04[a]

Commodity	*Level ($m, average three years ended)*		*Change*	*Contribution to growth*	*Annual average growth*
(TREC 6-digit)	*1990-01*	*2003-04*	*($m)*	*%*	*%*
Japan					
Beef & veal, chilled or frozen	812.8	1504.2	691.4	41.6	4.8
Wood chips	375.7	688.4	312.7	18.8	4.8
Unprocessed food nes	75.2	472.7	397.5	23.9	15.2
Cheese	60.3	333.7	273.4	16.4	14.1
Prepared animal feed	73.0	250.3	177.3	10.7	9.9
United States					
Beef & veal, chilled or frozen	951.1	1488.0	536.9	32.2	3.5
Wine of fresh grapes	20.8	789.0	768.2	46.1	32.3
Mutton & lamb, chilled or frozen	26.7	305.1	278.5	16.7	20.6
Rock lobster, fresh or chilled	74.5	90.4	16.0	1.0	1.5
Unprocessed food nes	15.7	53.7	38.0	2.3	9.9
China					
Greasy or fleece washed wool	107.5	1067.7	960.2	55.9	19.3
Sheep & lamb skins (wool on)	2.2	118.2	116.0	6.8	36.1
Cotton, not carded or combed	27.4	90.7	63.3	3.7	9.7
Other wool	77.5	88.7	11.3	0.7	1.1
Inedible beef & mutton tallow	8.0	88.0	80.0	4.7	20.3
United Kingdom					
Wine of fresh grapes	41.3	863.2	822.0	96.4	26.4
Mutton & lamb, chilled or frozen	22.9	77.2	54.2	6.4	9.8
Beef & veal, chilled or frozen	41.9	39.7	-2.1	-0.3	-0.4
Cheese	9.1	18.3	9.2	1.1	5.5
Live animals (excl sheep/lambs)	0.1	12.8	12.7	1.5	50.2
New Zealand					
Processed food nes	25.0	129.4	104.4	14.5	13.5
Wine of fresh grapes	16.4	94.9	78.5	10.9	14.4
Sugar & chocolate confect.	27.2	78.2	51.0	7.1	8.5
Prepared animal feed	16.8	61.8	45.0	6.3	10.5
Cereal preparations nes	13.2	58.9	45.7	6.4	12.2

[a] Contribution figures sum to more than 100 due to declines in other commodities over the period.

Source: DFAT (STARS Database 2005).

From the mid-1950s onwards, Australia increasingly directed its agricultural exports to Pacific rim countries and away from the United Kingdom and Europe. The key factor driving these changes were the formation of the European common market in 1948 and the United Kingdom's accession to the European Economic Community in 1973. The corresponding loss of preferential access by Australian farmers to the United Kingdom market led to a fundamental change in Australian export destinations. For example, in the early 1950s, almost 40 per cent of total Australian merchandise exports were sold to the United Kingdom, around 80 per cent of which were agricultural exports, predominantly wool and beef. By 1990-91, the United Kingdom share had fallen to 3.6 per cent of Australian merchandise exports, of which 21 per cent were agricultural exports.

Despite the growth in the United Kingdom market over the past decade and a half, the overall trend away from selling agricultural products on European markets has continued. Not only did the European Union's (excluding the United Kingdom) share of Australian agricultural exports fall 11 percentage points between 1990-91 and 2003-04 to account for around 6 per cent of Australian agricultural exports, but the value of agricultural sales also fell by almost $0.6 billion in current prices. This was driven, in particular, by falling export sales to France (down $233 million), Italy (down by $178 million) and Germany (down by $177 million) over the period (figure 4.14).

In contrast, exports to ASEAN countries increased strongly. Driven by strong growth in exports to Indonesia, Thailand and the Philippines, ASEAN's share of Australian agricultural exports increased from 7 to 13 per cent of agricultural exports.

Overall, Australian agricultural producers have maintained solid rates of export growth over the past decade and a half through a combination of securing strong growth in a number of new export markets as well as consolidation of existing markets. In addition to cost-reducing productivity improvements (such as developments in aquaculture) and the adoption of other technical innovations[15], an essential element of the success of agricultural exports in recent decades has been continued high levels of responsiveness by Australian producers to consumer demand in export markets. Some examples include: the development of a grain-fed cattle industry to meet Japanese consumers' preferences for 'marbled' beef; the supply of suitable live sheep as well as Halal-certified meat from Australian processing firms to Middle Eastern customers for traditional cooking; providing either whole lobsters (to Asia) or lobster tails (to the United States) depending on market preference; and the use of air freight by Australian suppliers to ensure

[15] Such as the use of new varieties of plants and crops including the Pink Lady apple, new grape and wine varieties and insect-resistant cotton (DFAT 2004a).

exports of processed meat, lobster, tuna, vegetables and cut flowers are delivered fresh to market (DFAT 2004a).

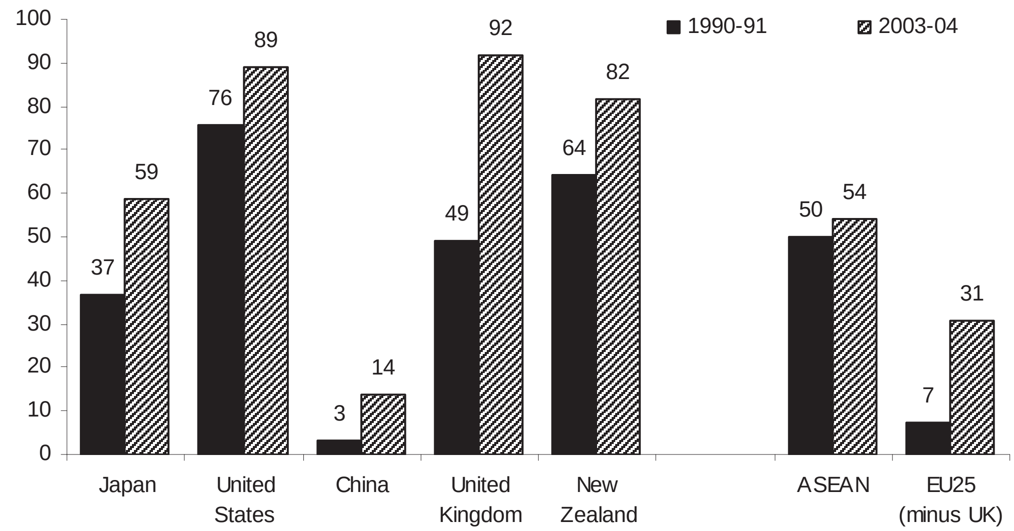
Processed food exports

An important driver of the growth in agricultural exports over the past decade and a half has been processed foods. This growth has been broadly based, with processed foods increasing their share of agricultural exports to most of Australia's key export markets. As noted earlier, caution needs to be exercised in interpreting these data as the 'processed food' category is very broad and contains a number of processed agricultural products that have undergone only a low level of processing (such as chilled and frozen beef) as well as some more highly processed products (such as wine) (DFAT 2004b).

In 1990-91, processed foods accounted for 37, 76 and 3 per cent of agricultural exports to Japan, the United States and China respectively. By 2003-04, these shares had risen sharply — to 59 per cent for Japan, 89 per cent for the United States and 14 per cent for China (figure 4.15).

Figure 4.15 **Share of processed food in agricultural exports to key markets, 1990-91 and 2003-04**

Per cent, current prices (average three years ended)



Data source: DFAT (STARS Database 2005).

The switch away from unprocessed agricultural products has been particularly marked in Japan. The composition of exports has changed markedly, with processed foods almost doubling their share over the period. This was due largely to strong growth in chilled and frozen meat exports (particularly in 2003-04 following the positive United States BSE result discussed earlier) coupled with sharp declines in the value of wool exports over the period.

Between 1990-91 and 2003-04, processed foods increased as a proportion of agricultural exports to most of Australia's major agricultural export markets. Higher income countries generally exhibited higher shares of processed food imports. For example, processed foods made up around 90 per cent of total imports of Australian agricultural products by the United Kingdom and the United States in 2003-04. By contrast, processed food exports to China (14 per cent), India (3 per cent) and Pakistan (18 per cent), although growing, remain relatively small.

4.5 Barriers to growth in Australia's agricultural exports

With only limited scope for domestic consumption growth, the Australian agriculture sector's future growth is highly dependent on world markets. As the President of the National Farmers' Federation recently said (Corish 2004, p. 10):

> With Australia exporting about 70 per cent of what we produce, continued and expanded access to global markets through multilateral and bilateral trade deals is one of the keys to our future.

There are, however, significant institutional impediments to growth in agricultural trade arising from the agricultural support policies of many countries.

Worldwide, agriculture continues to be the most highly protected sector. It has higher tariffs on average than any other sector and has significant non-tariff barriers to trade. It is also the only sector for which WTO rules permit the use of export subsidies.

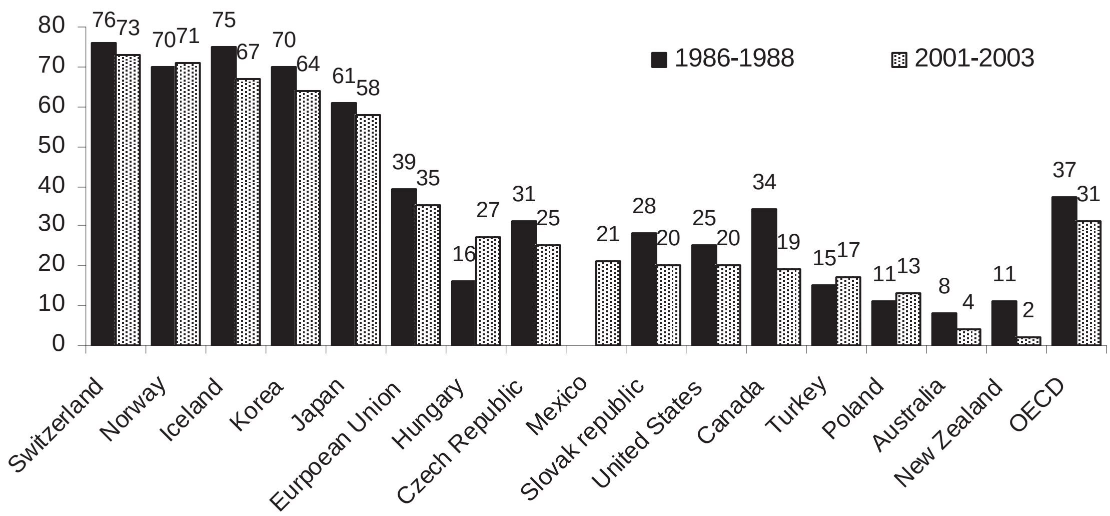
It is estimated that OECD countries transfer around $US 300 billion to agriculture via government support policies each year — equivalent to around 1.3 per cent of GDP or just over 30 per cent of farm receipts (OECD 2003a).

Support measures in these countries include import tariffs, domestic subsidies and export subsidies. A common feature of these measures is that they support farmers' incomes which, in turn, impacts on production decisions and international trade.

Producer support as a share of gross farm receipts among OECD countries is highest in Switzerland, Norway, Iceland, Korea Japan and the European Union (figure 4.16).[16] In contrast, Australia provides the second lowest level of support to agriculture, after New Zealand, among OECD countries. Australia's low result reflects a combination of generally low rates of assistance to agriculture in conjunction with a series of microeconomic reforms since the mid-1980s such as dismantling of statutory marketing arrangements and price support schemes (box 4.4).[17]

Figure 4.16 **OECD agricultural producer support estimates by country, 1986-1988 and 2001-2003**

Percentage of value of gross farm receipts



Data source: OECD , PSE/CSE Database (2004b).

[16] The producer support estimate measures the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, at the farm-gate level, arising from policies that support agriculture, regardless of their nature, objectives or impacts on farm production or income (OECD 2004).

[17] The Commission's assistance estimates are discussed in more detail in its Trade and Assistance Review 2003-04 (PC 2004c).

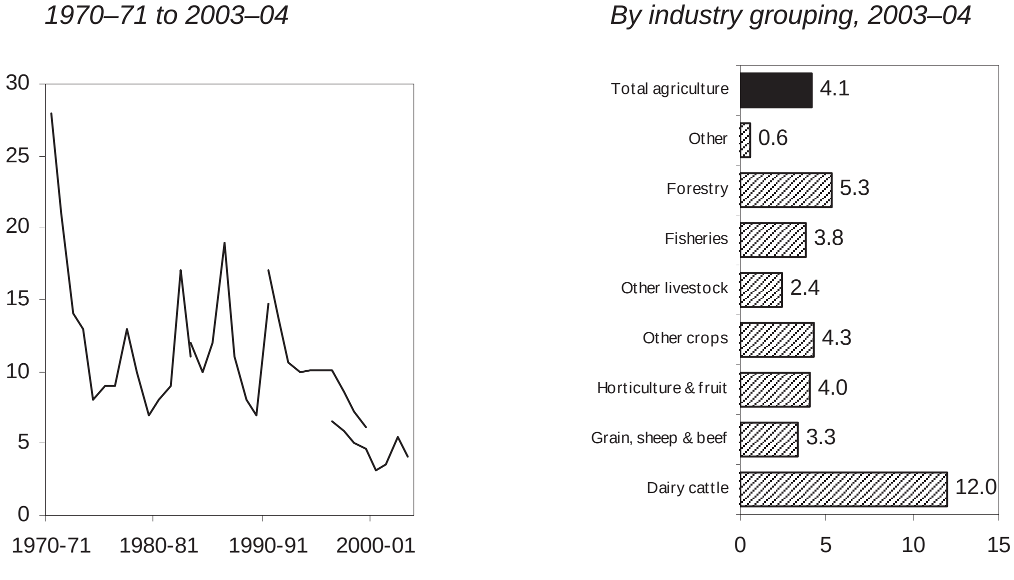
Box 4.4 **Government assistance to agriculture**

Australian Governments have employed a wide range of measures to provide assistance to the agricultural sector. These include statutory marketing arrangements, tariffs and budgetary measures such as adjustment assistance, R&D support, drought relief and tax concessions. From the mid-1980s, governments began to dismantle statutory marketing and price support schemes which provided the bulk of measured assistance to agriculture as part of a wider program of microeconomic reform. Key industries affected by these changes included dairy, sugar, eggs and tobacco.

The Commission's effective rates of assistance (ERAs) estimates reveal that assistance to agriculture is inherently volatile due largely to fluctuations in world commodity prices. Nevertheless, average ERAs for agriculture declined from around 13 per cent in the 1970s to an average of 5 per cent in the seven years to 2003-04 (figure 4.17) although this figure excludes 'exceptional circumstances' drought payments. Over the same period, assistance to manufacturing declined from around 28 per cent in the 1970s to around 6 per cent in the decade to 2003-04. The latest data series reveals that agriculture's ERA's have declined at 0.3 percentage points a year, on average, since 1997-98 to reach 4.1 per cent in 2003-04. Dairy cattle farming remains the most highly assisted industry with an ERA of 12 per cent in 2003-04, followed by forestry (5.3 per cent) and other crops (4.3 per cent).

Figure 4.17 **Average effective rates of assistance[a] to agriculture**

Per cent



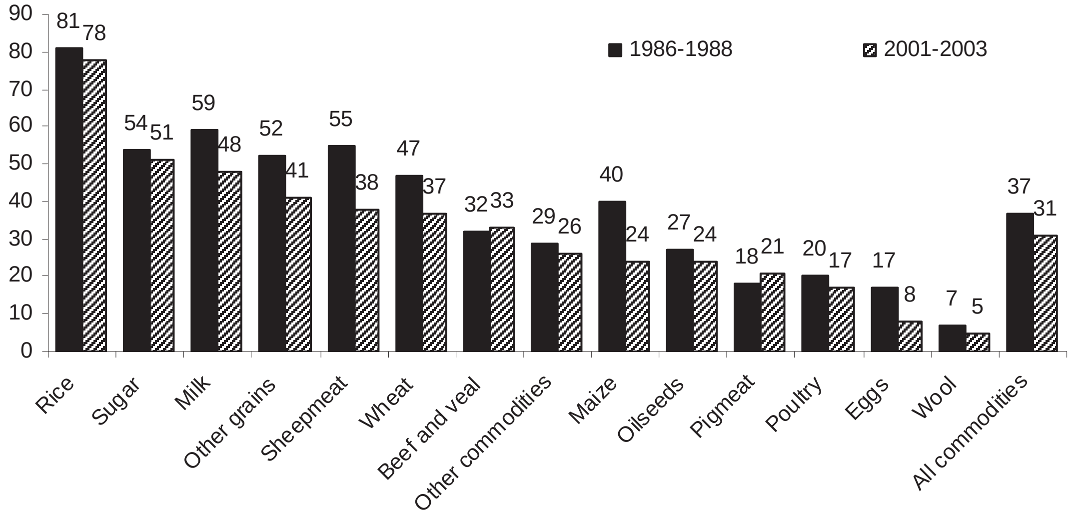
[a] The effective rates of assistance is the dollar value of measured assistance divided by unassisted value-added. For agriculture, this includes tariff assistance, most budgetary assistance and, the main component, assistance provided by domestic regulatory and pricing arrangements. Breaks in the series reflect the effects of periodic revisions to reference data covering industry inputs and outputs.

Source: PC (2003, 2004c).

There is considerable variation in producer support estimates for commodities across OECD countries, with rice, sugar and milk receiving the highest levels of support while wool, eggs, poultry, pigmeat and oilseeds receive the least support (figure 4.18).

Figure 4.18 **OECD producer support estimates by commodity[a], 1986-1988 and 2001-2003**

Percentage of value of gross farm receipts



[a] Rates are average most favoured nation applied rates which were used during the Uruguay Round.

Data source: OECD PSE/CSE database (2004b).

And, while there is evidence of some progress in reducing protection to many of the commodities within the sector since the mid to late 1980s — the average producer support estimate for the OECD dropped from 37 per cent in 1986-88 to 31 per cent in 2001-03 — government support for the agriculture sector remains high. As noted by ABARE (Roberts et al. 1999, p. 14):

> Agriculture has been the poor relation when it comes to international efforts to advance economic benefits from more open and less distorted international markets. Government intervention and the associated market distortions for agriculture have been, and remain, very large. This is particularly the case in developed countries.

The high level of agricultural support affects returns to Australian farmers by reducing world prices and limiting access to markets through various quantitative restrictions (such as import quotas and embargoes). As Andrews et al. (2003, pp. 5-6) put it:

> It is in Australian farmers' interest to reduce agricultural support globally. Such action will reduce the competition from subsidised farmers faced by Australian producers on world markets, increase consumption in the large protected markets and lead to higher world market prices. Less distortion in world markets translates into higher and more

stable prices for Australian exporters and producers of agricultural products. Therefore, multilateral trade reform matters for Australian farmers and rural communities.

Various Australian and international studies have identified substantial potential gains from further liberalisation of agricultural trade both for Australia and the rest of the world (box 4.5).

Box 4.5 **Projected gains from liberalisation of agricultural trade**

A number of Australian and international studies suggest that there are substantial gains to be made from further liberalisation of trade in agriculture. For example:

- An Australian study by Dee and Hanslow (2000), estimated that the world as a whole would be better off by more than $US260 billion annually as a result of eliminating all post-Uruguay trade barriers. About $US50 billion of this was projected to come from agricultural trade liberalisation. As expected, liberalisation of trade in agricultural products is projected to encourage resources to shift out of the relatively highly protected sectors in Japan, Korea, the Philippines and the European Community. In contrast, the agricultural sectors of countries such as Australia, New Zealand and the United States were projected to expand in response to more liberal markets for agricultural products.
- A study by the Economic Research Service of the United States Department of Agriculture (2001) found that the full elimination of all agricultural policy distortions would yield long-term global welfare gains of $US56 billion a year.
- ABARE (Freeman et al. 2000) estimated that a 50 per cent cut in agricultural protection between 2005 and 2010 would lead to global welfare gains of $US53 billion a year by 2010.
- Work by ABARE (Andrews et al. 2003) suggests that the Cairns Group proposals before the current WTO trade round would result in a $2.1 billion increase in Australia's gross national product by 2010. This would have favourable flow on effects for Australian farmers with average cash incomes for broadacre and dairy farmers estimated to rise by $10 900 and $15 500 respectively.

Sources: Dee and Hanslow (2000), Economic Research Service of the United States Department of Agriculture (2001), Freeman et al. (2000), Andrews et al. (2003).

However, progress in reforming remaining barriers to trade has been slow, and it seems likely that the potential benefits from global agricultural trade reform will not be realised for some time. As in the past, key challenges facing Australian agricultural producers continue to be how to respond to pressures resulting from the secular decline in their terms of trade and increased competition from existing, as well as newly emerging suppliers. In the face of these pressures, continuing improvement in farm productivity will be crucial in maintaining farm incomes. The productivity performance of the agricultural sector is examined in chapter 6.

5 Agriculture's workforce

Key points

- In 2003-04, agriculture, forestry and fishing employed 375 000 people — 85 per cent were employed in agricultural jobs, 7 per cent in services to agriculture and 7 per cent in forestry, logging, and commercial fishing.
- Agricultural employment, while variable between years, has exhibited only a very slight downward trend over the last four decades — declining on average by less than half of one per cent a year. The 2002-03 drought, however, had a significant impact — a decline of 15 per cent or around 70 000 jobs (12 months to June 2003) — the largest recorded employment shock of any drought since reliable statistics became available.
- Grain, sheep and beef cattle farming combined, are the sectors' biggest employers (44 per cent), followed by horticulture and fruit growing (25 per cent).
- Agriculture is an important employer in rural and regional Australia. In 2001, it directly accounted for almost 14 per cent of non-metropolitan employment and for more than 25 per cent of total employment in 207 of Australia's 425 labour regions.
- Agriculture's share of total Australian employment has more than halved since the 1960s, down from 9 to just under 4 per cent in 2003-04.
- Agriculture's workforce has a number of distinctive features. Compared to other sectors of the economy it has a high proportion of self-employed, family and casual workers. It is also a relatively old workforce with relatively low education levels, long job tenure and low employee wages.
- The last two decades, however, have seen some convergence in the characteristics of the agricultural workforce relative to the workforce in general. There has been an increase in the number of employees in the sector and a fall in employers and contributing family workers. The educational attainments of agricultural workers have improved and this has been at a faster rate than for the general workforce.
- Off-farm employment has become increasingly important to maintaining family farm incomes. Between 1989-90 and 2002-03, the proportion of farm families deriving income from off-farm wages and salary increased from 30 to 45 per cent and average earnings from such sources more than doubled, in real terms, rising from $15 000 to $33 500 per year.

This chapter examines the structure of the agricultural workforce and highlights the features that distinguish agriculture from labour markets elsewhere in the economy. The chapter also looks at how agriculture's workforce has changed over the last twenty years and the factors influencing these changes.

5.1 Agriculture jobs

In 2003-04, agriculture, forestry and fishing employed 375 000 people or around 4 per cent of Australia's workforce (table 5.1). Just over 85 per cent of those employed in the sector are employed in agricultural jobs, around 7 per cent are employed in providing services to agriculture (such as shearing and cotton ginning), and the remaining 7 per cent are employed in forestry, logging and commercial fishing.

Table 5.1 **Agriculture employment, 2003-04[a]**

Industry/sector	*Number employed 2003-04*	*Proportion of agriculture's workforce*
	'000 persons	%
Agriculture, Forestry and Fishing	375	100
Agriculture	320	85.5
Horticulture and fruit growing	95	25.3
Grain, sheep and beef cattle	166	44.0
Dairy cattle	20	5.3
Poultry	10	2.6
Other livestock	10	2.7
Other crops	11	2.9
Services to agriculture	25	6.7
Forestry and logging	12	3.2
Commercial fishing	16	4.2

a Employment data presented in this chapter are based on the average of the four consecutive quarters between August and May in the nominated year, with the exception of 1984-85 where data are averaged over the three quarters November 1984 to May 1985.

Source: ABS (Cat no. 6291.0.55.001).

Agriculture's biggest employers are grains, sheep and beef cattle (combined they account for 44 per cent of the workforce), followed by horticulture and fruit growing (25.3 per cent) and services to agriculture (6.7 per cent) (table 5.1).

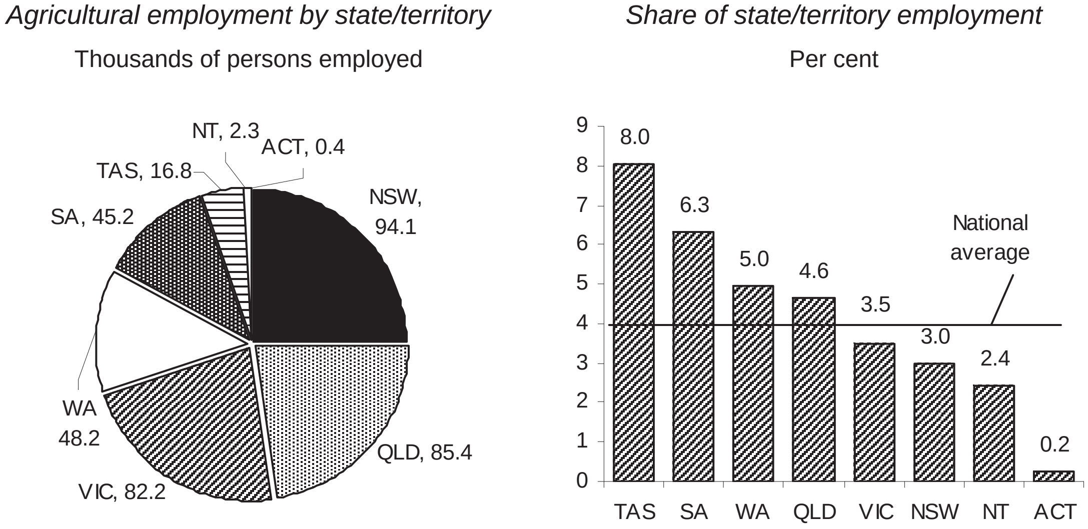
Distribution of agricultural employment

About 25 per cent of the agricultural workforce is employed in New South Wales and just over 20 per cent in each of Queensland and Victoria. The Northern

Territory and the Australian Capital Territory combined employ less than 1 per cent of the agricultural workforce (figure 5.1).

Agriculture's share of state employment, however, is stronger in Tasmania (8 per cent), South Australia (6.3 per cent), Western Australia (5 per cent) and Queensland (4.6 per cent), than the larger states (Victoria and New South Wales) and the territories, which all recorded shares below the national average of around 4 per cent (figure 5.1).

Figure 5.1 **Agricultural employment in the states and territories, 2003-04**



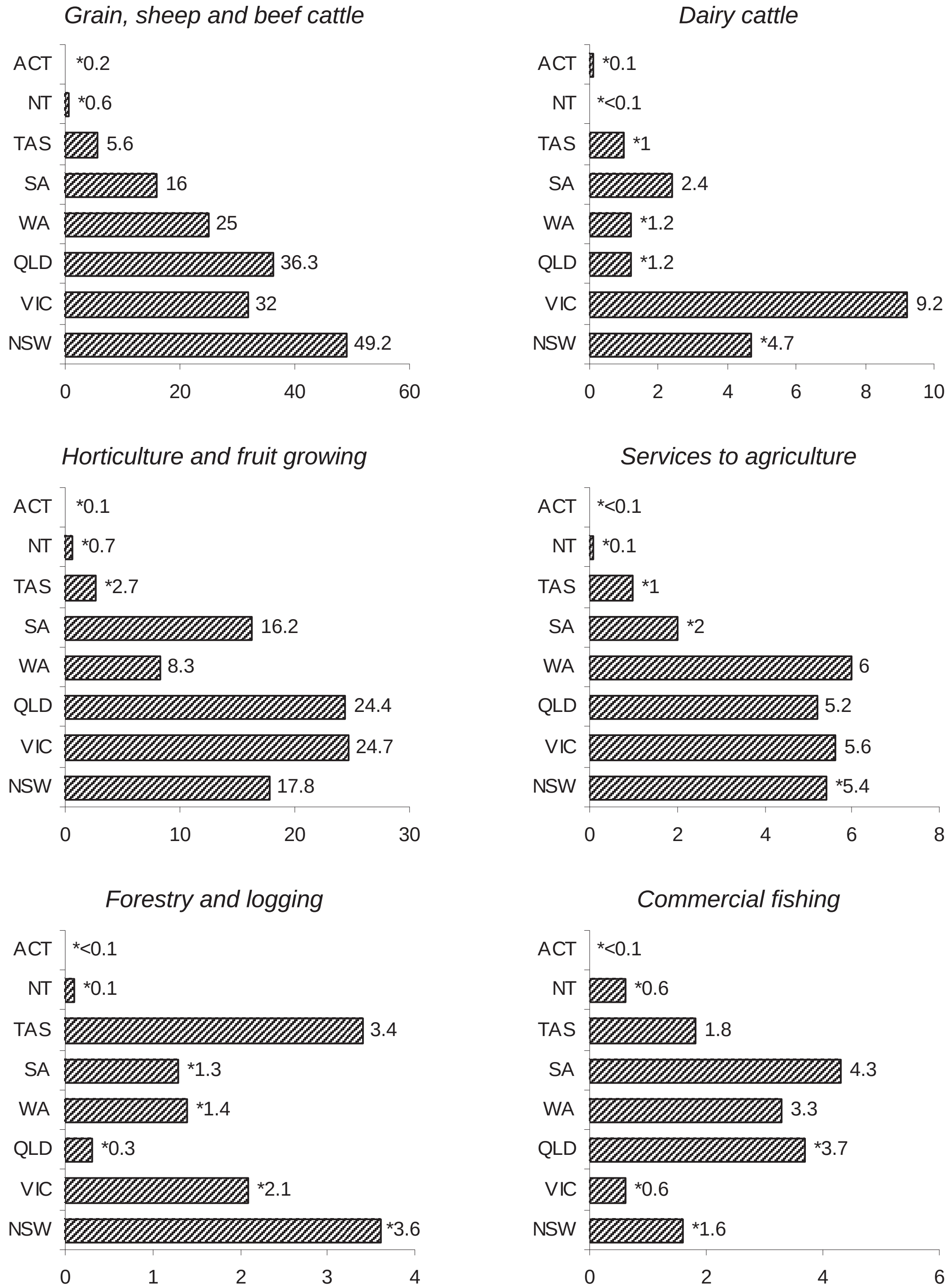
Data source: ABS (Cat. no. 6203.0).

An examination of the distribution of employment by industry also reveals some diversity among the states (figure 5.2, also see appendix C, table C.1). For example:

- grain, sheep and beef cattle industries account for just over 50 per cent of all agriculture, forestry and fishing employment in New South Wales;
- dairy employment is predominately located in Victoria;
- around half of all employment in the horticulture and fruit growing industry is located in Victoria and Queensland;
- New South Wales, Victoria, Queensland and Western Australia dominate employment in services to agriculture, reflecting the distribution of total agricultural employment;
- more than half of all employment in the forestry industry is located in New South Wales and Tasmania; and
- one-quarter of commercial fishing employment is located in South Australia.

Figure 5.2 **Distribution of agricultural employment in selected industries by state and territory, 2003-04[a]**

‘000 persons



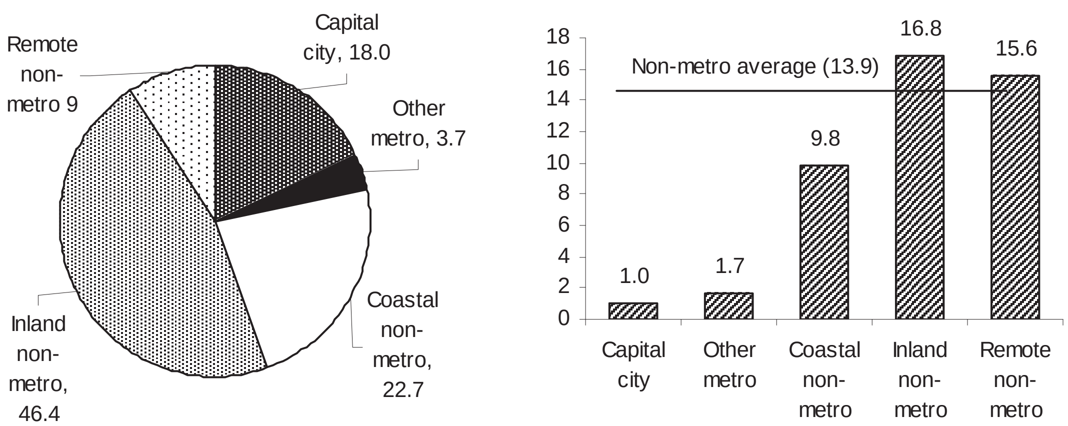
[a] Data are based on survey information, and so information for Agriculture, Forestry and Fishing subdivisions and groups, or at state and territory level, is less reliable than more aggregate information at division or national level. Estimates with a relative standard error of 25 per cent or greater are preceded by an asterisk (for example, *5.2) to indicate they are subject to high standard errors and should be interpreted with caution.

Data source: ABS (Cat no. 6291.0.55.001).

Agriculture is an important employer in rural and regional Australia. In 2001, almost four-fifths of agricultural employment was located in non-metropolitan regions. (By comparison, just over a quarter for all employment is located in non-metropolitan regions.) Inland regions account for almost half of all agricultural employment, coastal non-metropolitan for around one quarter while remote regions account for almost 10 per cent (figure 5.3).

Agriculture also accounted for around 14 per cent of all non-metropolitan employment and for almost 17 per cent of employment in inland non-metropolitan regions in 2001 (figure 5.3). And for 207 of Australia's 425 labour market regions, agriculture directly accounted for more than 25 per cent of total employment.

Figure 5.3 **Agricultural employment shares by region[a], 2001**
Per cent



[a] The five regional groupings are based on the BTRE's reworking of the 2001 ABS Remoteness Structure which groups Census Collection Districts into broad classes of remoteness sharing common characteristics in terms of physical distance from services and opportunities for social interaction. This classification divides Australia into 425 regions — 8 capital city regions, 6 other metropolitan regions (comprising Gold Coast/Tweed, Townsville-Thuringowa, Sunshine Coast, Newcastle, Wollongong and Geelong), 89 coastal non-metropolitan regions, 199 inland non-metropolitan regions and 123 remote non-metropolitan regions.

Data source: BTRE (Industry Structure Database 2004).

The regional distribution of agricultural employment, however, varies across industries. For example, over 50 per cent of employment in plant nurseries, cut flower and seed growing and poultry farming was located in metropolitan regions. Other agricultural industries highly represented in metropolitan areas include fruit and vegetable growing, horse farming, services to agriculture, fishing and aquaculture. Most traditional broadacre agricultural industries such as beef, sheep, grains and dairy have non-metropolitan employment shares of between 90 to 95 per cent (see appendix C, table C.2).

Employment linkages with other sectors of the economy

As discussed in chapter 2, agriculture has important linkages with other sectors of the economy and indirectly contributes to employment in industries such as food processing and fibre manufacturing. The employment numbers discussed above, therefore, understate the relative importance of agriculture in terms of employment dependant upon the sector.

Food Processing

The food processing industry — which includes abattoirs, wineries, flour millers and fruit processors — is the second largest manufacturing subdivision. In 2003-04, it employed 170 800 people or 16 per cent of total manufacturing employment (see appendix C, table C.3). It has also been one of the fastest growing manufacturing industries over the last twenty years (PC 2003).

The distribution of food processing employment across the states and territories reflects the location of the agricultural activities that provide intermediate inputs these industries. Meat processing plants, for example, are more highly represented in states with larger reliance on livestock industries such as Queensland and New South Wales. For similar reasons, Victoria and South Australia have disproportionately high shares of dairy and beverage (wine) manufacturing respectively.

As is the case with direct employment in the agriculture sector, a large share of food processing employment is located in non-metropolitan regions (around 40 per cent) — the highest share recorded by a manufacturing subdivision (ANZSIC basis, see appendix C, table C.4).

Other manufacturing industries

In addition to food processing, there are a number of other manufacturing industries that either provide direct inputs to the agricultural sector — such as the production of agricultural machinery, pesticides and fertilisers — or rely heavily on non-food inputs for processing — such as saw mills and wool scouring. Combined, these industries employed another 39 000 people in 2001, the majority of which (54 per cent) were in non-metropolitan regions (see appendix C, table C.5).

Service industries

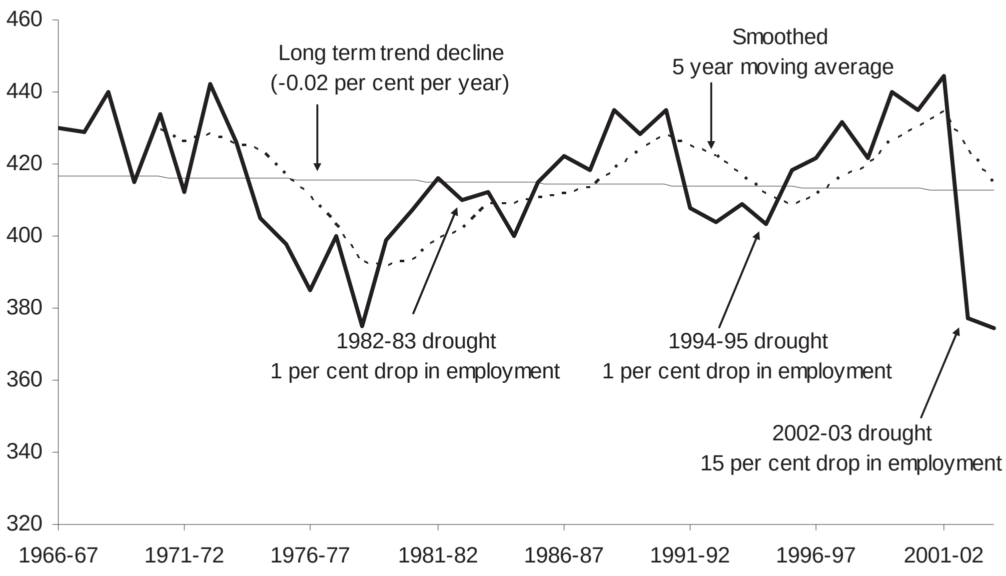
A range of industries providing services to the agriculture sector — such as grain storage, veterinary services, and the wholesaling of wool, meat, timber and farm machinery — employed a further 109 000 people in 2001. Almost half of these (45 per cent) are employed in non-metropolitan regions (see appendix C, table C.6).

5.2 Trends in agricultural employment

Agricultural employment, while exhibiting significant variability between years, has been relatively flat over the last four decades — declining by a trend rate of less than half of one per cent a year over the period 1966-67 to 2003-04 (figures 5.4 and 5.5).

From the mid-1960s through to the late 1970s, agricultural employment declined by around 1 per cent a year. This coincided with a period when capital was being substituted for labour — much of the new technology at that time was embodied in capital (Knopke et al. 1995). The decade of the 1980s saw modest growth, although employment declined by around 1 per cent during the 1982-83 drought.

Figure 5.4 **Employment in agriculture, 1966-67 to 2003-04[a]**
'000 persons

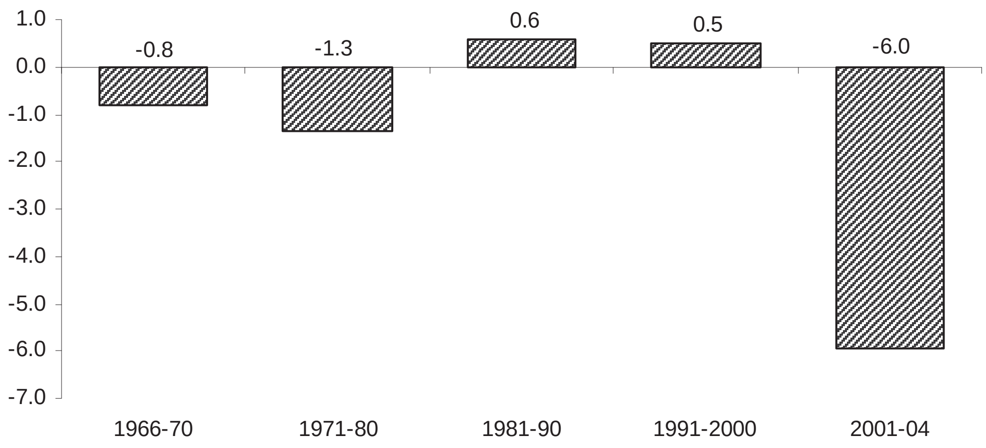


[a] The trend growth rate was estimated by regressing the logged value of employment against a time trend for the years 1966-67 to 2003-04.

Data sources: ABS (Cat no. 6291.0.55.001); RBA from Econdata.

Figure 5.5 **Trend annual employment growth, agriculture, forestry and fishing, 1966 to 2004,**

Per cent



Data source: ABS (Cat no. 6291.0.55.001).

Agricultural employment declined in the early 1990s, largely driven by job losses on sheep farms — the decline of the sheep flock from 174 million in 1989 to 120 million in 1994-95 coincided with a fall of around 15 000 in the total number of employees in the broadacre sector (Knopke et al. 1995). From a low point during the 1994-95 drought, agricultural employment increased, reaching a peak of around 440 000 in 2001-02.

Triggered by the 2002-03 drought, the 12 months to June 2003 saw the loss of around 70 000 agriculture jobs, or a decline of around 15 per cent (figure 5.4). This decline represents the largest employment shock of any drought since the 1960s (when reliable statistics became available). By comparison, both the 1982-83 and 1994-95 droughts resulted in job losses of around 6000, or a decline of around one per cent. The magnitude of the job loss (one job in six) during the latest drought overshadows the tradition of long term stability of agriculture employment.

Declining share of total employment

While in absolute terms employment in agriculture has remained relatively constant over the last four decades, agriculture's contribution to Australia's total workforce has more than halved since the late 1960s, when it accounted for around 9 per cent of the workforce. Agriculture declined to around 6.5 per cent of the workforce from around the mid 1970s, before falling further to around 5 per cent in the decade to 2001-02. Employment losses associated with the most recent drought saw agriculture's share fall to under 4 per cent in 2003-04.

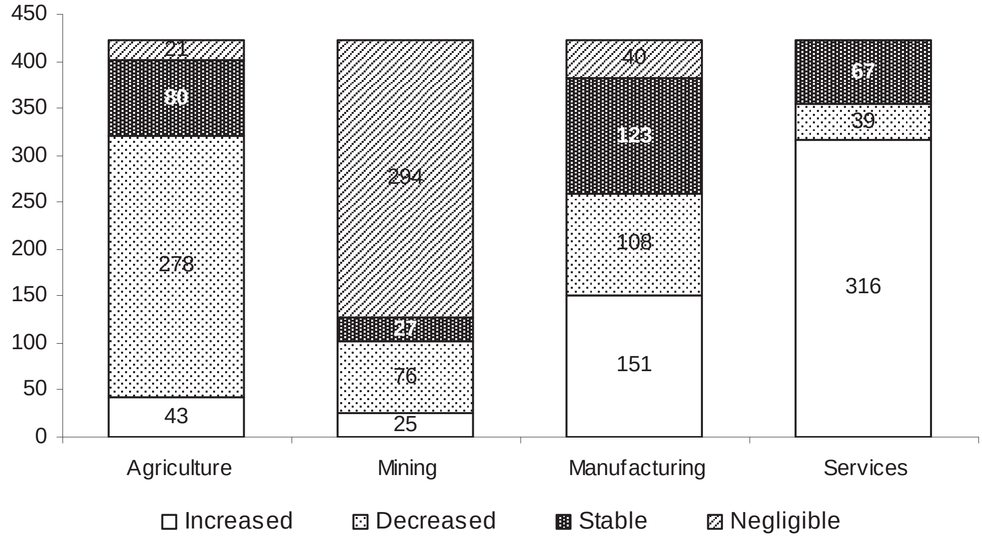
Employment changes in regional Australia

Following the trend in total agricultural employment, the sector's share of regional employment declined over the past decade, while remaining relatively stable in absolute terms.

Census data shows that over the decade to 2001, agricultural employment:

- declined in two-thirds (278) of Australia's 425 regions;
- increased in ten per cent (43) of regions; and
- remained stable in around one-fifth of regions (figure 5.6).

Figure 5.6 **Industry employment share changes across Australia's regions[a], 1991 to 2001**



[a] Regions with a stable sector share are those in which the employment share changed by less than 1 percentage point. Regions with a negligible sector share comprise those in which the employment share was less than 1 per cent in 1991 and remained so in 2001.

Data source: BTRE (Industry Structure Database 2004).

With total agricultural employment remaining relatively stable over the decade, these declining shares have been driven by faster growth of employment in services. Overall, services increased as a share of employment in three-quarters of all regions and declined as a share in less than 10 per cent (figure 5.6).

Many of the falls in the share of agriculture were quite small, in the order of 1-2 percentage points. The number of regions in which agriculture directly accounted for more than 25 per cent of employment remained relatively stable — down from

221 in 1991 to 207 in 2001. Hence, despite the growth in services employment over the period, agriculture remains a key source of employment in regional Australia.

Changing employment shares within agriculture

The last two decades have also seen changes in the structure of the agricultural workforce. One of the reasons for this has been the differing rates of employment growth among agricultural industries.

Services to agriculture experienced the strongest employment growth over the period 1984-85 to 2001-02 — around 70 per cent or 10 000 additional jobs — to become the third largest employer in the sector. In part, this reflects the use of specialist skills through contractors and changing employment practices (box 5.1). Other agricultural industries recording relatively strong employment growth include commercial fishing, other crops, dairy and horticulture and fruit growing (see appendix C, table C.7)

Agricultural industries recording employment losses over the period 1984-85 to 2001-02 included — other livestock (down 42 per cent), forestry and logging (down 8 per cent) and grain, sheep and beef farming (down 3 per cent).

Box 5.1 **Farmers making greater use of specialised services**

The last few decades have seen changes in the skill set required by farm managers. Technological advancements, larger farms and greater awareness of environmental issues, have all meant that farmers are increasingly required to have a diverse set of skills. As Ferguson and Simpson (1995, p. 95) observe:

> Today's farm manager requires, more than ever, sound financial and risk management skills, rigorous pursuit of technological advances, a level of marketing knowledge and sound land and water management practices. All these skills are in addition to the specialist animal husbandry and/or agronomy skills required for each particular agricultural industry.

One of the outcomes of the increased knowledge and skills requirement of farmers is a significant growth in specialist contractors and consultants servicing the agriculture sector. With the growing complexity of farm management, farmers are hiring or leasing machinery and equipment, buying in services such as marketing and business management services, and seeking advice in areas such as agronomy (crop and soil management).

This trend is reflected in a rapid growth in employment in agricultural services — over the two decades to 2003-04, employment in this industry increased by almost 70 per cent, or by around 10 000 jobs.

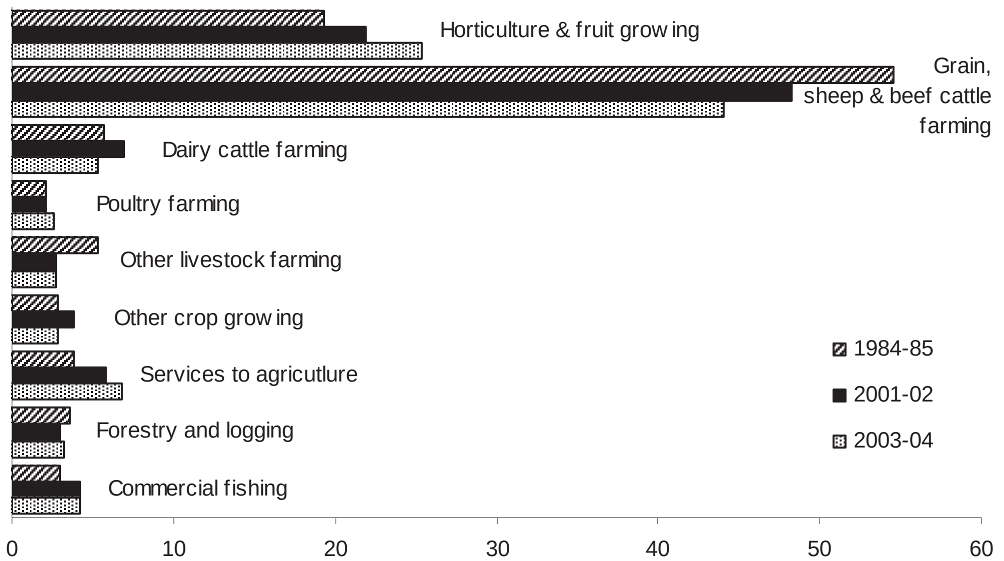
Source: Ferguson and Simpson (1995).

Over period 2001-02 to 2003-04, all agriculture industries (with the exception of poultry) experienced job losses. Losses were minimal in both horticulture and fruit growing (2.5 per cent) and services to agriculture (2 per cent). While the largest job losses occurred in the dairy industry (down 36 per cent or around 11 000 jobs), and other crop growing (down 37 per cent or around 6000 jobs). In the case of the dairy industry, this also coincided with the period of adjustment following further deregulation of the industry.

Higher employment growth rates in some of the more labour intensive industries have meant that some of these industries — horticulture and fruit growing, services to agriculture, poultry farming and commercial fishing — have tended to gain relative employment share over the last two decades. Industries losing employment share include grains, sheep and beef cattle farming, dairy, other livestock farming and forestry and logging (figure 5.7).

Figure 5.7 **Industry share of agricultural employment, 1984-85, 2001-02 and 2003-04**

Per cent



Data source: ABS (Cat no. 6291.0.55.001).

5.3 Some distinctive features

The agricultural workforce has a number of distinctive features. Compared with other sectors of the economy agriculture has:

- a high proportion of self-employed, family and casual workers;
- long job tenure;
- a relatively old workforce;

- a low incidence of post-school qualifications; and
- low employee wages.

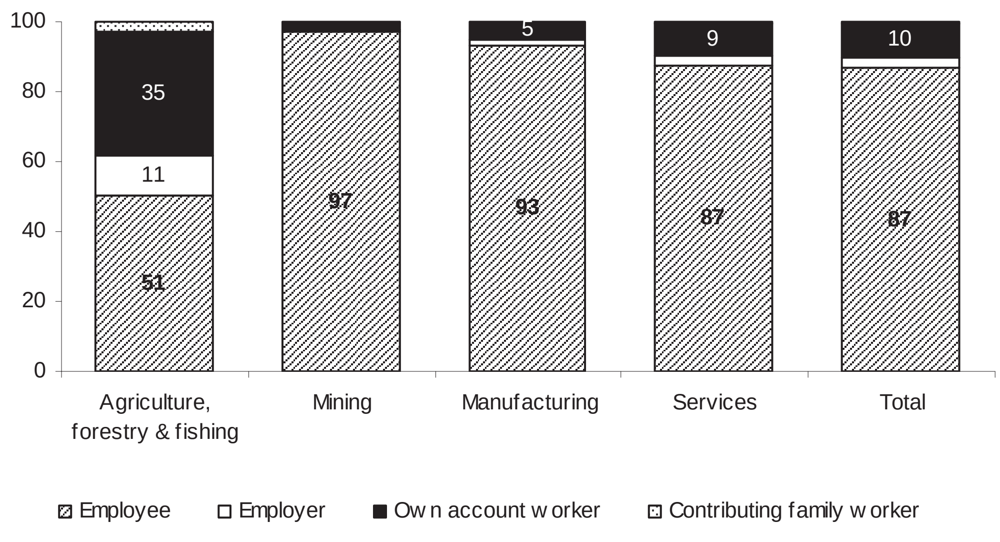
Many of these features arise from the dominance of family operated businesses in this sector (99 per cent of Australian farms are family owned and operated), which provides flexibility in the use of labour in terms of hours worked and engagement in off-farm work. This section looks at trends in the distinguishing features of agricultural employment over the last 20 years, and provides comparisons with labour markets in other sectors of the economy.

A high proportion of self-employed and family labour

The agriculture workforce has a high proportion of self-employed (employers and owner account workers). In 2003-04, employers accounted for 11 per cent of the workforce and own account workers for 35 per cent. This compares with 3 per cent of employers and 10 per cent of owner account workers for the workforce as a whole. Employees make up around half the agriculture workforce, compared to more than 85 per cent for the workforce generally (figure 5.8).

Figure 5.8 **Status of employment by sector[a], 2003-04**

Per cent



[a] Employee — a person who works for an employer and receives fiscal remuneration; or a person who operates their own incorporated enterprise with or without hiring employees. Employer — a person who operates their own unincorporated enterprise or engages independently in a profession or trade, and hires one or more employees. Own account worker — a person who operates their own unincorporated enterprise or engages independently in a profession or trade, and hires no employees. Contributing family worker — a person who works without fiscal remuneration in an enterprise operated by a relative.

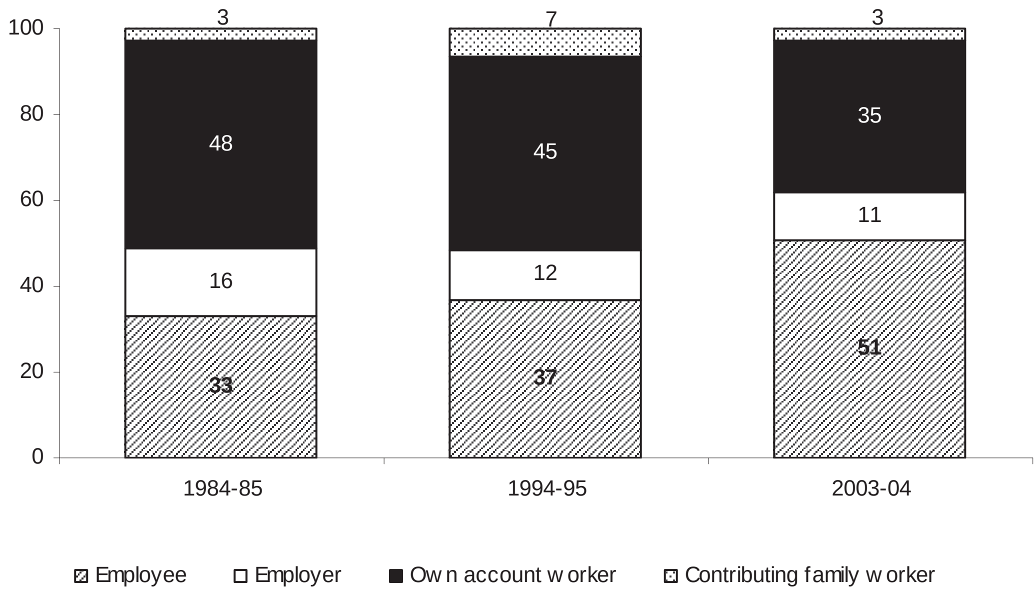
Data sources: ABS (Cat no. 6291.0.55.001), ABS Labour Statistics: Concepts, Sources and Methods (Chapter 4, 2001).

Agriculture is also the sector making greatest use of family labour — almost 3 per cent of the workforce in 2003-04 compared with less than 1 per cent for the workforce as a whole.

Over the last twenty years, the proportion of employers, own account workers and contributing family workers have all declined (figure 5.9). Most notable has been the fall in own account workers, from 48 per cent of the total workforce in 1984-85 to 35 per cent in 2003-04. The proportion of employees, on the other hand, increased from 33 per cent to be just over half of the total workforce in 2003-04.

Figure 5.9 **Status of employment in agriculture, forestry and fishing, 1984-85, 1994-95 and 2003-04**

Per cent



Data source: ABS (Cat no. 6291.0.55.001).

Employment losses resulting from the 2002-03 drought caused a decline in all categories of agricultural workers. With the exception of contributing family workers, the proportional decline was most pronounced amongst employers, amounting to around 20 per cent. Lu and Headley (2004, p. 38) suggest that one of the strategies adopted by farmers to contend with the effects of the drought was to reduce the level of on-farm employment, thus, in some cases, farmers changing their employment status from employer to own account worker.

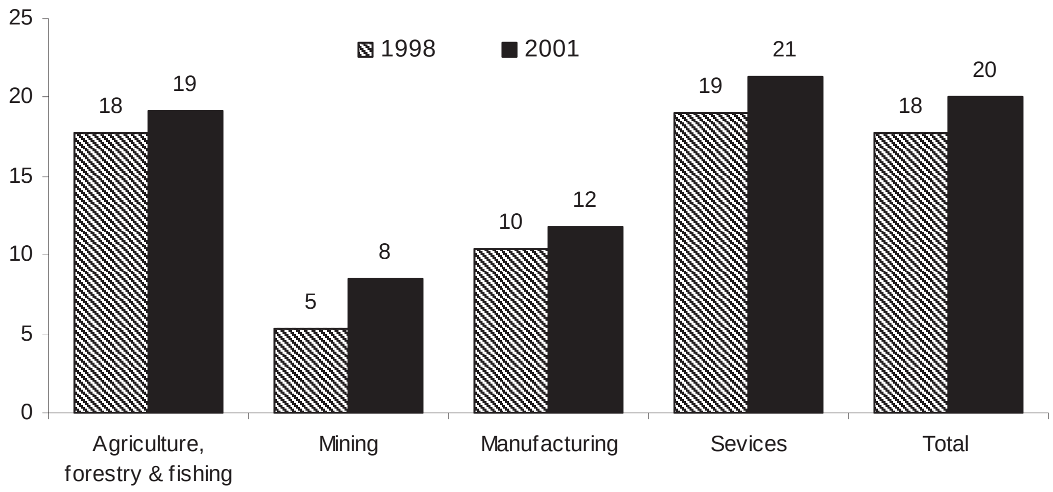
The increased reliance on paid employees in the agriculture workforce over the last 20 years, in part, can be linked to the trend towards larger farm sizes. Demographic changes such as smaller family sizes (fewer children to help on the farm) and other influences, such as more family members working off-farm, have also reduced the supply of family labour and, hence, increased the share of hired labour. Consistent with this, the number of paid employees per farm increased from around 2.1 in 1984-85 to almost 2.5 in 2002-03.

Casual and part-time labour

Agriculture also stands out as having a relatively high proportion of self-identified casual employees — almost 20 per cent of total employment — similar to that in the service sector, but significantly higher than in either mining or manufacturing (figure 5.10).

Figure 5.10 **Proportion of self-identified casuals in the total workforce, by sector[a], 1998 to 2001**

Per cent



[a] Self-identified casuals are persons who (a) were not entitled to receive both paid holiday and sick leave, (b) considered their job to be casual, and (c) worked in someone else's business or reported that they worked in their own unincorporated business but paid PAYE tax and did not invoice clients for own payment.

Data source: ABS (Cat no. 6359.0).

Factors contributing to this feature of agricultural employment include:

- the seasonal nature of agricultural work, for example, harvesting and shearing in broadacre industries or pruning and harvesting in horticultural industries, and
- the potential for workers to be employed by a number of employers (across several industries) thus, combining multiple and consecutive casual agricultural jobs in order to obtain continuous work (Rural Industry Working Group 2001).

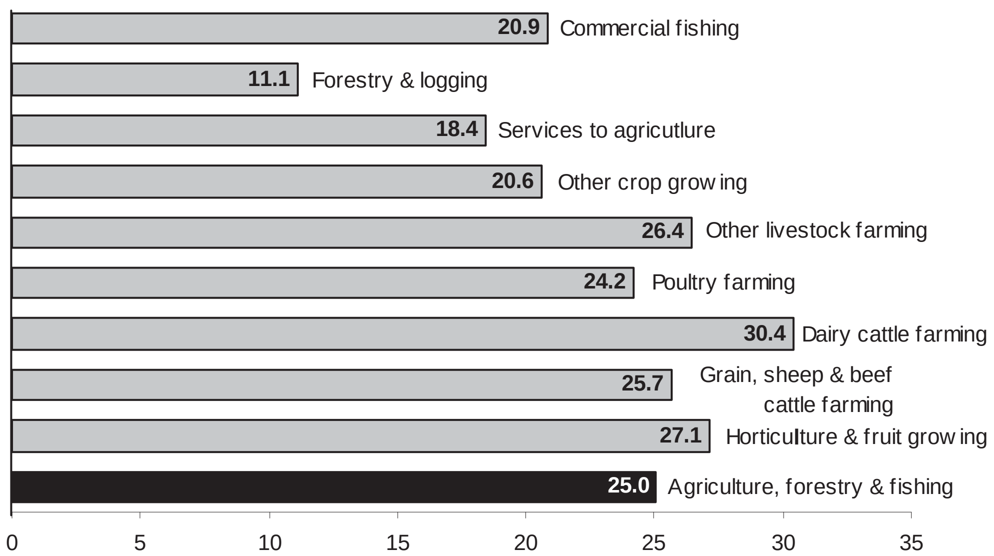
As with other sectors of the economy, there has been an increase in the use of casual labour in the agricultural sector (figure 5.10). This is likely to reflect changing labour supply demographics, demand for workforce flexibility and institutional changes (Murtough and Waite 2000).

Part-time jobs

In 2003-04, around a quarter of all agriculture jobs were part-time. This is considerably higher than the proportion of part-time jobs in both mining (4 per cent) and manufacturing (12 per cent), but lower than services (31 per cent).

Some agricultural industries rely more on part-time employment than others. Agricultural industries with a relatively high proportion of part-time employment include dairy, horticulture and fruit growing and other livestock. Forestry and logging, where the nature of the work tends to be structured more like that of the manufacturing sector, stands out as having a relatively low proportion of part-time employment (figure 5.11).

Figure 5.11 **Part-time employment by industry, 2003-04**
Per cent



Data source: ABS (Cat no. 6291.0.55.001).

In the early 1980s, agriculture recorded a relatively high proportion of part-time jobs. However, over the last 20 years, part-time jobs in the sector increased at a slower rate than part-time jobs in the economy more generally. As such, since 1991-92, the part-time share of employment in agriculture has dropped below that for the economy as a whole (see appendix C, table C.8 and C.9).

In 2003-04, there were around 5000 more females employed in part-time jobs than in full-time jobs in agriculture. This is a long term feature of female employment in agriculture, with part-time employment remaining slightly greater in absolute terms than full-time employment throughout most of the last 20 years (box 5.2). In all other sectors of the economy, the share of females in full-time employment is greater than the share in part-time employment.

Part-time employment in agriculture has also become more prevalent for males. Over the period 1984-85 to 2003-04, the proportion of males employed in part-time jobs increased from 5 to 9 per cent.

Box 5.2 **Women on Australian farms**

Over the last two decades, the proportion of women employed in agriculture increased from 26 to 31 per cent (women employed full-time in agriculture increased from 12 to 15 per cent, while those employed in part-time employment increased from 14 to 16 per cent).

The role of women on Australian farms has also changed in recent decades. As Barr (2002, p. 3), put it:

> Few women living on farms today identify with the once traditional role of ‘farmers wife’. They are increasingly likely to identify as a joint farm manager or as having an occupational life separate from the farm business. It has been estimated that women number 40 per cent of farm business partners and 32 per cent of the farm paid workforce. Many women work off the farm to support farm family living standards.

Some of the factors driving the changing role of women in agriculture include changes to the demographic composition and economic situation of family farm households, the growth of part-time employment, as well as changes in the returns to labour, both in farming and in off-farm work.

Work by ABARE (Gooday 1995, p. 8) has shown that the extent and nature of women’s contribution on Australian farms varies widely. Some women work alone on the farm and are solely responsible for the decision making and the operation of the farm. Others have numerous responsibilities, such as assisting on the farm during peak times, doing the farm accounts and undertaking financial management and planning for the farm.

(Continued on next page)

Box 5.2 **(continued)**

Women in the dairy industry spend significantly more time working on-farm than women in broadacre industries, while women in the broadacre industries tend to spend more time in off-farm employment.

ABARE has also found that women's involvement in farm activities declines as the size of the farm increases — generally the average number of weeks worked on-farm by women is lower for farms of more than 200 hectares. Similarly, the average number of weeks worked off-farm by women tends to be lower for farms with higher capitalisation. And, as debt levels increases, there is a corresponding increase in the time women spend working both on and off-farm.

There also appears to an inverse relationship between the amount of time worked on-farm and off-farm and the level of income generated by the farm enterprise — the average number of weeks worked off-farm by both women and men tend to be lower for those farms with higher farm income. According to Gibson, Baxter and Kingston (cited in Salce, 1995 p. 331) women's labour both on and off-farm, particularly in poor seasons, has been 'crucial in maintaining the family income, particularly of family farms in recessions'.

Sources: Barr (2002); Salce (1995); Garnaut, Rasheed and Rodriguez (1999); Gooday (1995).

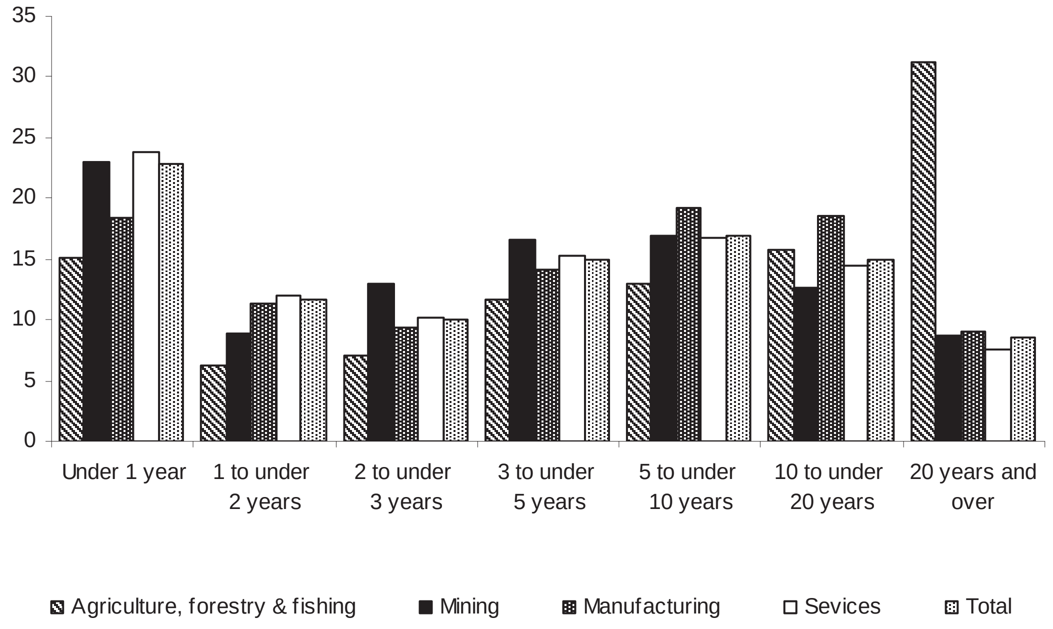
Farmers stay in their jobs longer

The agriculture workforce is characterised by relatively long job tenure. In 2004, around 50 per cent of the agriculture, forestry and fishing workforce had been in their current job for 10 years or more — a share almost double that seen in other sectors of the economy. And, about 30 per cent of the agriculture workforce had spent 20 years or more in their current job, a share more than three times higher than in other sectors of the economy (figure 5.12).

This trend is not new — in 1983 around 40 per cent of agricultural workers had worked in their current job for 10 years or more. It reflects, in part, the high proportion of family owned and operated farms in Australia and the significant financial investment tied to assets on the farm. But as noted by Barr (2004, p. 7) other factors are relevant, including that:

> '[F]or many persons working in agriculture, farming is felt to be not just an occupation but a way of life'.

Figure 5.12 **Years working in current job by sector, 2004**
Per cent



Data source: ABS (Cat no. 6209.0).

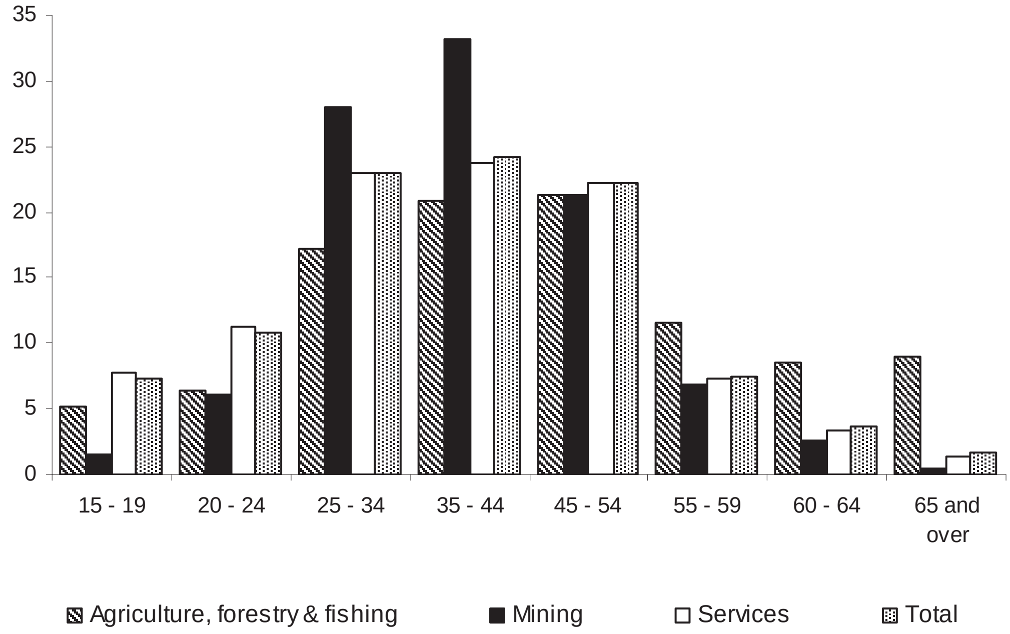
… and this is reflected in the sectors age profile

The agriculture workforce is also older on average than the workforce in general (figure 5.13). In 2003-04, around 71 per cent of the agriculture workforce were aged 35 years or older. This compares with around 59 per cent of workers in all industries (see appendix C, table C.10)

Several factors have contributed to the skewed age profile of workers in the agriculture sector compared to other sectors of the economy, including:

- fewer young people entering farming;
- low exit rates at traditional retirement age, possibly compounded by limited interest of young people in taking over the family farm; and
- delayed exit decisions in response to reduced farm capital during poor seasons or reduced market values during periods of low commodity prices (Barr 2004).

Figure 5.13 **Age profile of agricultural workers, by industry 2004**
Per cent



Data source: ABS (Cat no. 6291.0.55.001).

Reflecting the tendency for those working in the sector, particularly those in farming, to work beyond the traditional retirement age, the share of agriculture's workforce aged 65 or older is significantly higher than in other sectors of the economy. In 2003-04, there were around 9 per cent of agricultural workers aged 65 years or over — this is more than 4 times the percentage of workers in this age category in the workforce generally.

Using census data, Barr (2004) estimates that the median age of agriculture workers has increased from 44 in 1981 to 50 in 2001. The results for each census year between 1976 and 2001 indicate that the median age reached a minimum in 1981, but has been increasing at a uniform rate over the last two decades.

There are, however, differences in the age profile of workers in the different agriculture industries. Both the beef and sheep industries have a more aged worker profile than the more labour intensive industries (see appendix C, figure C.1). In 2001, almost half of the workers in the beef industry were aged 55 years or older. In contrast, the horticulture and dairy industries had younger age profiles, with less than 25 per cent of workers in each of these industries aged 55 years or older. Barr (2004, p.42) suggests that:

> The differing age profiles of agricultural industries suggests that the increasing median age of Australian farmers may be due to differential adjustment patterns within industries.

Qualification and occupational profile

Agriculture workers typically have lower levels of formal tertiary qualifications than workers in other sectors of the economy. The proportion of the agriculture workforce:

- without post-school qualifications is around 20 percentage points higher than for the workforce generally (61 per cent compared to 42 per cent); and
- with university training is more than three times lower than that for the workforce generally (table 5.2).

Table 5.2 **Educational attainment in the Australian workforce, 1984, 1994 and 2004[a]**
Per cent

	University degree			*Other post-school qualifications*			*Without post-school qualifications*		
Sector	*1984*	*1994*	*2004*	*1984*	*1994*	*2004*	*1984*	*1994*	*2004*
Agriculture, forestry & fishing	**2.3**	**4.5**	**6.8**	**23.8**	**23.8**	**31.4**	**73.1**	**70.0**	**61.0**
Mining	8.1	14.4	17.3	44.8	35.8	46.7	47.1	49.8	35.3
Manufacturing	4.5	7.2	13.1	35.0	36.7	40.3	60.2	55.5	45.8
Services	11.7	16.5	24.3	35.5	32.5	34.1	51.1	48.4	40.7
Total	9.6	14.6	22.4	34.5	32.7	34.9	54.5	50.4	41.9

[a] Other post-school qualifications include vocational training and all other non-university diplomas and certificates. It also includes (the small populations of) people who are still at school.

Sources: ABS (Cat no. 6227.0); Unpublished ABS data.

As is the case for the workforce generally, the educational attainment of agriculture workers has been increasing. While starting from a lower base, agriculture has tended to exhibit stronger growth in educational attainment in its workforce. For example, between 1984 and 2004, the proportion of university graduates in the Australian's workforce more than doubled, while for agriculture the proportion of university graduates almost tripled.

The last decade has also seen a rapid increase in the share of workers with other post-school qualifications. And, despite the increase in the prevalence of university qualifications amongst the agriculture workforce, there remains a greater share of workers with other post-school qualifications — non-university studies, in particular trade and vocational qualifications gained through the vocational, education and training sector.

In assessing the qualifications and skills profile of workers in the agriculture sector, recognition needs to be given to traditional arrangements within the sector for the development of work skills — largely dominated by on-farm learning undertaken as part of employment (Cullen and Cullen 1994, p. 11 and Synapse Consulting 1998, p. 12). However, as Cary et al. (2001, p. 24) suggest:

> It is reasonable to assume, increasingly in the future, that more complex sustainable management practices will be more easily grasped and integrated into farming systems by those with higher levels of formal education.

In comparison to the rest of the economy, the agriculture workforce is dominated by managers and administrators (again reflecting the dominance of owner-operators), with the next most prevalent occupation being labourers and related workers (see appendix C, table C.11).

Earnings

Agriculture has a high proportion of relatively low paid employees compared with other sectors of the economy. In 2003, 68 per cent of all full-time agriculture employees earned less than $700 per week. This compares with 40 per cent of full-time workers across all sectors of the economy. Fourteen per cent of agriculture workers earned in excess of $1000 per week, compared with almost 30 per cent of workers in all sectors of the economy (figure 5.14).

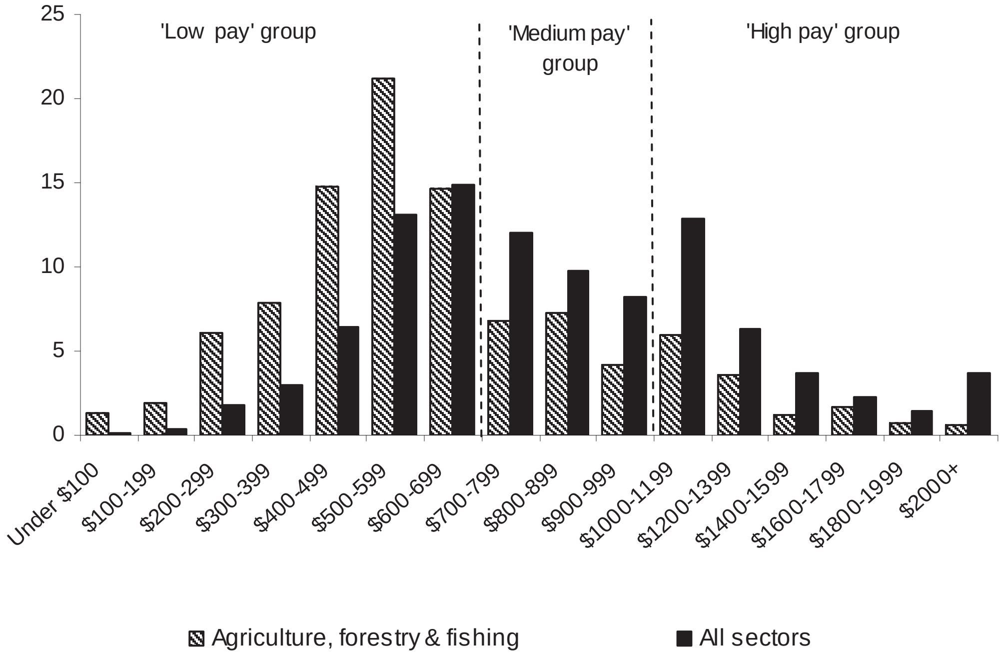
The median weekly earnings for full-time paid employees in agriculture in 2003 was $575. This was around one third lower than the median weekly income for all full-time employees ($769), making agriculture workers the lowest paid workers in the economy. The next lowest paid, on average, were employees in the retail trades ($600) and accommodation, cafes and restaurants ($610).

However, there are often non-wage benefits available to employees in agricultural jobs — such as low cost accommodation and other payments in kind — which may compensate, to some extent, for the sector’s relatively low wages.

These data, however, only relate to full-time employees and as such exclude the self-employed (own account workers and employers) and other family labour which account for around half of the agricultural workforce.

Figure 5.14 **Distribution of paid employees by weekly full-time earnings[a], August 2003**

Per cent



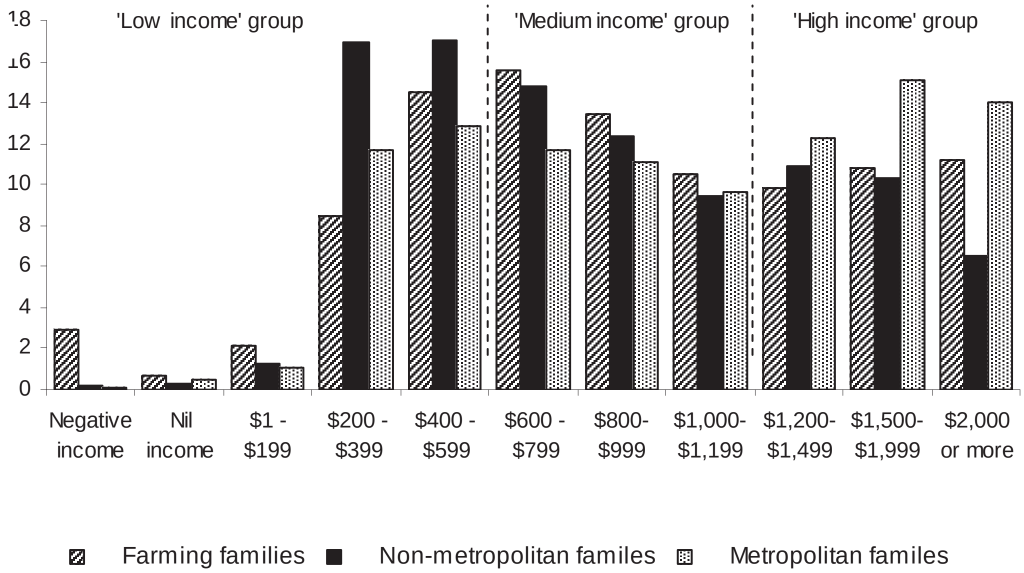
a These data refer to weekly earnings in main job for full-time paid employees and as such exclude the self-employed (own account workers and employers) and other family labour which account for around half of the agricultural workforce. Following McLachlan et al. (2002), the three groups were structured so that each accounted for as close to one third of total employment as possible – low, medium and high accounting for 40, 30 and 30 per cent respectively of Australia's total employment.

Data source: ABS (Cat no. 6310.0).

Compared to the distribution of full-time employees' earnings, the distribution of income for farming families more closely resembles that in the rest of the economy (figure 5.15). In 2001, around 29 per cent of farming families had relatively low incomes (less than $600 per week) — the same proportion of low income families as the rest of the economy. There was, however, a greater proportion of farming families earning negative incomes. That said, a higher proportion of other non-metropolitan families — around 36 per cent — had relatively low incomes (less than $600 per week) in 2001.

Figure 5.15 **Distribution of gross weekly income for farming families, other non-metropolitan families and metropolitan families[abc], 2001**

Per cent



[a] Gross weekly income is self-reported and includes various government payments or benefits such as, family payments, additional family payments, pensions, unemployment benefits, student allowances, maintenance payments (child support), as well as non-government income from superannuation, wages, salary, overtime, dividends, rents received, interest received, business or farm income (less operating expenses) and workers' compensation. [b] Excludes families where one or more persons did not state their income. [c] Metropolitan is defined as capital city urban centres and any other urban centres (or part urban centres) in the state with a population over 100 000 (Gold Coast/Tweed Heads, Canberra/Queanbeyan, Newcastle, Central Coast, Wollongong, Sunshine Coast, Geelong, Townsville-Thuringowa).

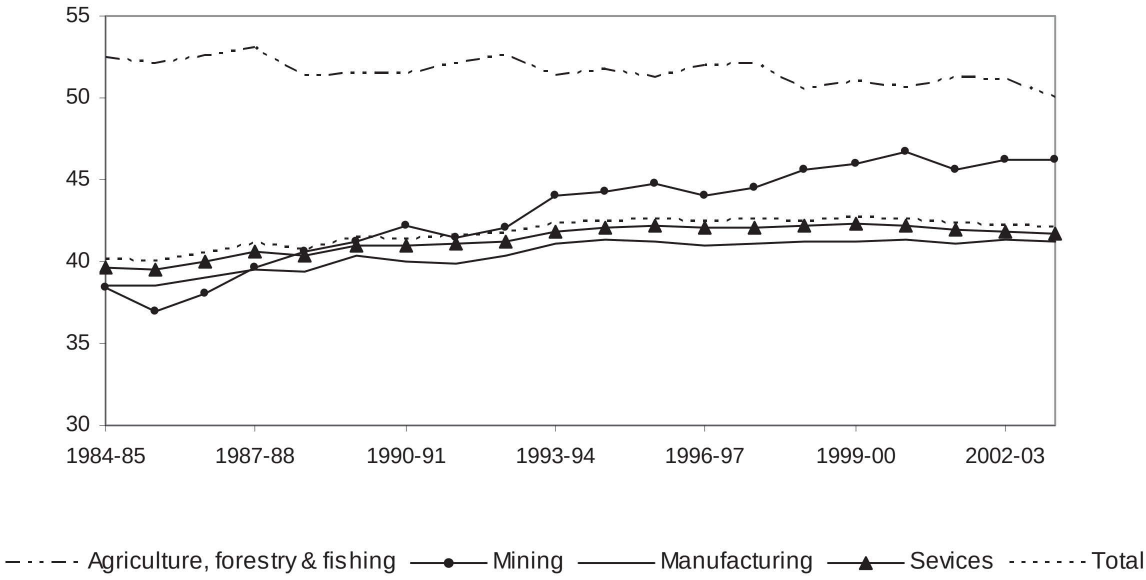
Data source: Unpublished ABS data.

Work intensity

Agriculture workers also work more hours per week than workers in other sectors of the economy. In 2003-04, full-time agriculture workers worked an average of 50 hours per week. This compares with 42 for the total workforce.

Over the last twenty years, however, average hours worked by those employed full-time in agriculture have fallen by 2 hours per week. This trend is the reverse of that exhibited in the other sectors of the economy where average working hours have increased by 2 hours per week (figure 5.16). As the average working week in agriculture dropped from 12 to 8 hours greater than the economy-wide average, this has lead to the convergence of average hours worked by workers in all sectors of the economy over the period 1982-83 to 2003-04.

Figure 5.16 **Average full-time hours per week worked in main job, 1984-85 to 2003-04**



Data source: ABS (Cat no. 6291.0.55.001).

Factors likely to have influenced the rate of decline in hours worked by those working full-time in agriculture include:

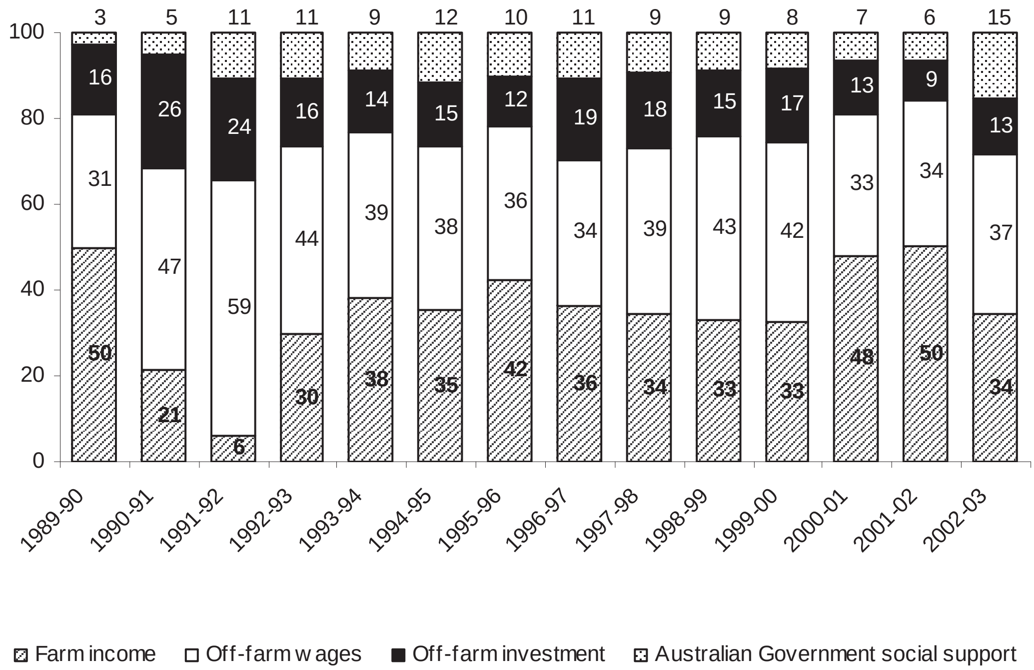
- trends within the sector toward labour saving technologies and intensification (chapter 3); and
- an increase in the incidence of off farm work (see following section). This may have reduced the number of hours an individual works in agriculture, although their total average hours worked per week may not have declined.

ABARE farm surveys data regarding the source of farm labour for broadacre industries shows that total hours worked by 'other' family members (apart from the farm operator and spouse), paid permanent and casual workers and sharefarmers has remained relatively stable at around 30 hours per week in the years since 1994-95. This suggests that the reduction in average working hours has been concentrated among employers and own account workers — that is, the farm operator and spouse.

Off-farm income

The contribution of off-farm income — that is, off-farm wages and salaries investment dividends, rents and other business income and government social support payments — has averaged around 65 per cent of the total income of broadacre farm families between 1989-90 and 2002-03, not being less than 50 per cent in any single year (figure 5.17). Variations in the contribution of off-farm income between years largely reflects the volatility of income from farm production (figure 5.17).

Figure 5.17 **Income sources for broadacre farm families[abc]**
Per cent



a Includes only the broadacre industries surveyed by ABARE: wheat and other crops, mixed livestock-crops, sheep, beef and sheep-beef industries. **b** Excludes off-farm income from employment in a business owned or part-owned by the operator or spouse. **c** Includes social security, student assistance and veterans' payments made to the farm operator and spouse only, and excludes payments targeted to businesses, such as fuel rebates, structural adjustment and exceptional circumstances payments or payments received by other family members, such as youth allowance.

Data source: ABARE farm surveys data.

Off-farm employment has become increasingly important to maintaining broadacre family farm incomes. Over the period 1989-90 and 2002-03:

- the proportion of farm families who derive a share of their income from off-farm wages and salaries increased from 30 to 45 per cent; and
- average annual broadacre farm income earned from off-farm wages and salaries more than doubled in real terms — from $15 000 (31 per cent of average farm income of $82 000) to around $33 500 (37 per cent of average farm income of $137 500).

Off-farm work is typically undertaken by spouses (in most cases the female partner (Garnaut et al. 1999)). Since 1989-90, the average number of off-farm hours worked by spouses involved in broadacre industries has more than doubled, from 4 to 9 hours in 2002-03. And, while less common, there has also been a marginal increase in the participation of farm operators in off-farm work, involving an increase of about one hour per week between 1989-90 and 2002-03, to an average of 4 hours per week (box 5.3).

Box 5.3 **Gender differences in off-farm work**

Other than participation rates, notable gender differences also occur in terms of the location of off-farm work and the distribution of off-farm jobs by occupation and industry.

Garnaut et al. (1999) found that around 84 per cent of women with off-farm jobs work in towns, with two thirds working in an urban centre with a population of more than 20 000. Women working off-farm largely work in managerial or professional occupations in the education (34 per cent) and health and community services industries (22 per cent).

In contrast, just over 40 per cent of men with off-farm jobs work in town, while 32 per cent work on other farms. The most common occupations for men working off-farm were labourers (42 per cent) and tradespersons (23 per cent), with almost as many men working in off-farm jobs in the agriculture, forestry and fishing sector (47 per cent) as in all other industries combined.

Source: Garnaut et al. (1999).

As participation in off-farm work involves a trade-off with on-farm activities, several factors have had an influence on farm families' decisions and abilities to participate in off-farm work, including:

- education levels. Off-farm employment tends to be associated with higher education levels for both men and women (Rasheed et al. 1998);
- remoteness or distance to potential off-farm employment opportunities. Average incomes received from off-farm work tend to be lower for people living in remote locations, reflecting the more limited range of off-farm opportunities in these locations (Garnaut and Lim-Applegate 1998);
- labour requirements on the farm. Off-farm employment (both for farm operators and spouses) tends to be lower for those involved in industries with greater on-farm labour requirements, such as dairying. For example, in 1996-97, the share of operators and spouses with off-farm employment in the dairying industry was around 20 and 14 percentage points lower, respectively, than the share for those involved in broadacre industries (Rasheed et al. 1998); and

- the life cycle of the individual farm family. Young families, often those with dependent children, tend to rely more heavily on wages and salaries from off-farm employment as a mechanism to aid capital accumulation. Other off-farm income sources, such as investment dividends or rents, tend to be more important for older farm families who have had a longer period in which to develop investments capable of providing an ongoing income stream (Garnaut and Lim-Applegate 1998).

The greater contribution of off-farm income is not a phenomenon unique to Australian agriculture. The share of household income from off-farm sources has increased in most OECD countries over the last 20 years (OECD 2003b).

6 Agriculture's productivity performance

Key points

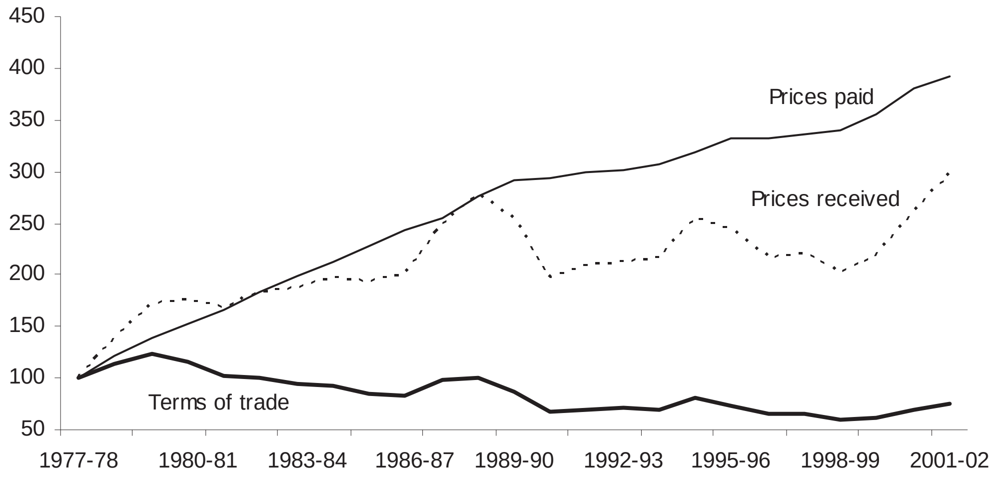
- Agriculture productivity, while quite volatile because of seasonal variations, has exhibited strong growth over the longer-term.
- Multifactor productivity (MFP) growth for the agricultural sector averaged almost 3 per cent a year over the period 1974-75 to 2003-04 (or 2.3 per cent a year in trend terms). This was considerably stronger than that achieved in Australia's market sector where the MFP growth rate averaged 1.1 per cent a year (1 per cent a year in trend terms) over the same period.
- Agriculture is a strong contributor to the economy's overall MFP growth. Over the period 1974-75 to 2003-04, it accounted for 16.5 per cent of market sector MFP growth. This was more than double it's share of market sector value-added.
- Agriculture has exhibited considerably stronger productivity growth from the mid-1990's — in trend terms, MFP increased by around 4 per cent a year between 1993-94 and 2003-04.
- Productivity growth has accounted for the entire increase in output by the agricultural sector over the last thirty years and has produced sizeable benefits — an estimated productivity 'dividend' of just over $170 billion.
- Over the last three decades, the highest productivity gains have been achieved by the cropping industry. Mixed crops-livestock, beef and dairy farms achieved the next highest growth rates. Productivity growth for sheep and sheep-beef farms has been modest and insufficient to offset the deteriorating terms of trade for these farms.
- Key sources of productivity growth include advances in knowledge and technology, better use of available technologies and management practices, and structural changes such as increases in farm size and shifts in enterprise mixes.
- International data suggest that, in 2001, labour productivity levels in Australian agriculture were below that for the United States and Canada, but above the OECD average by around 30 per cent. In terms of MFP growth, Australian agriculture has performed relatively strongly over the last two decades — recording a growth rate similar to the United States, but lower than Canada and Denmark.

This chapter looks at the productivity performance of Australia's agriculture sector over time and across agricultural industries. The chapter also compares Australia's agriculture sector experience with those of other sectors of the economy and other OECD countries. Factors influencing productivity growth in agriculture are also examined.

6.1 Productivity growth — why is it important?

Productivity growth is central to the performance and international competitiveness of Australia's agriculture sector. As discussed in chapter 4, most Australian farmers are highly dependent on world markets where they are largely 'price takers'. The past 25 years have seen world prices for many agricultural commodities decline significantly in real terms. Farmers are also often unable to exert any control over the prices they pay for their off-farm inputs to production. Over the period 1977-78 to 2001-02, prices received by Australian broadacre farmers increased, on average, by 2.3 per cent a year, while input costs over the same period increased by 4.8 per cent a year — the result being a decline in their terms of trade of 2.5 per cent a year (figure 6.1).

Figure 6.1 **Terms of trade, Australian broadacre farms, 1977-78 to 2001-02**
Index 1977-78 = 100



Data source: ABARE Farm Surveys.

Faced with a persistent declining terms of trade, the challenge for Australian farmers has been to find ways to improve productivity to reduce costs in order to remain competitive and maintain or improve farm incomes.

Productivity growth means that resources — such as labour, capital and land — are being used more effectively and efficiently. Increased output and lower costs means that with more income per head of population, Australians can enjoy a higher standard of living. It can also translate into lower food prices for consumers.

Productivity growth in the agricultural sector can also be beneficial for the environment — less land, water and chemicals to produce the same amount of output can mean reduced environmental problems associated with the use of such inputs.

6.2 Measuring productivity

What is productivity?

Productivity is a measure of the efficiency with which inputs are used to produce output.

There are a number of different productivity measures. Productivity *levels* are a measure of the ratio of output to inputs, for example, the number of litres of milk produced per dairy cow or crop yield per hectare.

Productivity *growth* is the amount of output growth in excess of input growth over a specified period, or put another way, the increase in output that cannot be accounted for by an increase in inputs. For example, if output grew by 6 per cent a year over a 10 year period and inputs grew by 4 per cent a year, productivity growth would be 2 per cent a year. Evidence of productivity growth usually means that ways have been found to create more output from given inputs, or alternatively, to produce the same output with fewer inputs.

How is productivity measured?

Productivity can be measured in relation to a single input — such as labour or capital — yielding a partial measure of productivity performance. *Labour productivity* is the most commonly used partial productivity measure. It is a useful measure as it typically relates to the single most important factor of production for many industries. It is also relatively easy to measure. Labour productivity reflects the influence of a host of factors, such as the personal capacities of workers, the intensity of their work effort, the nature and extent of capital equipment used and management practices. Similarly, *capital productivity* can reflect technological changes and changes in other factor inputs (including labour), as well as improvements in the organisation of production processes.

Multifactor productivity (growth in output relative to the combined contribution of key inputs, usually labour and capital) provides a more comprehensive performance measure as it takes account of changes in the main inputs used to produce output. MFP is, however, more difficult to measure.

The choice between the different measures is generally influenced by the purpose of productivity measurement but also, often on practical grounds, by the availability of data.

Measuring productivity for agriculture

Productivity in the agricultural sector is influenced by a range of factors, some of which are outside the control of the farmer. Seasonal variations, for instance, have a significant influence on farm output and input use and hence productivity. For this reason, when measuring productivity improvements 'attempts' should be made to isolate trend rates of growth from the effects of short-term influences.

Point-to-point estimates of productivity growth for agriculture can also be highly sensitive to the choice of start and endpoints. While short-term influences such as variations in rainfall can be expected to even out over extended periods of time, when estimating productivity growth it is important to consider the choice of start and end points to ensure that the years chosen are not 'atypical' (for example, a drought year).

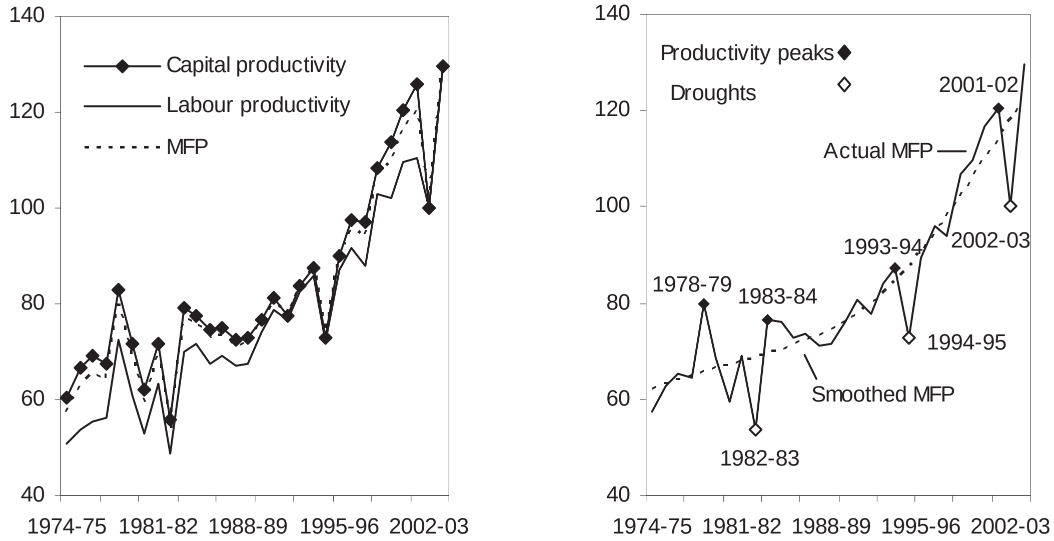
6.3 Trends in agricultural productivity

Agriculture productivity has exhibited strong growth over the longer-term. MFP growth for the agriculture sector — on the basis of start and end points — grew at 2.8 per cent a year from 1974-75 to 2003-04 (figure 6.2). This is considerably stronger than the productivity growth rate achieved for the Australian economy as a whole. The market sector[1] MFP growth rate over the same period was 1.1 per cent a year.

1 Data limitations make it difficult to analyse productivity growth for the economy as a whole. Analysis is therefore usually limited to the 'market sector' of the economy, or to those industries for which there are reasonably well defined output and input measures and associated prices. The industries excluded from the market sector include: property and business services; government administration and defence; education; health and community services; personal and other services. For these industries, output is not measured independently of inputs and, in most cases, 'value' is measured in terms of the cost of the labour inputs used by them.

Figure 6.2 **Labour, capital and MFP in the agriculture sector, 1974-75 to 2003-04[ab]**

Index 2001-02 = 100



[a] For a discussion of how peaks were determined see appendix D. [b] Trough to trough estimates are 2.6 per cent a year between 1982-83 and 1994-95 and 4.0 per cent a year over the period 1994-95 to 2002-03. The 'Smoothed MFP' series is calculated by smoothing the original data using a Hodrick-Prescott filter.

Data Source: PC (2004 Productivity Estimates to 2003-04, December, http://www.pc.gov.au/commission/work/productivity/performance/industry.html).

Growth in labour and capital productivity for the agriculture sector largely mirror growth in MFP. Over the period 1974-75 to 2003-04, labour productivity and capital productivity increased by 3.3 and 2.7 per cent a year, respectively (figure 6.2).

As is evident from figure 6.2, there has been considerable variation in agriculture's productivity growth from year to year. This is largely because of seasonal variations — drought effects on agriculture, for example, are evident in 1982-83, 1994-95 and 2002-03.

One way of isolating the long-run trend rates of growth in productivity from the short-term effects of seasonal influences is to use the data from all years and fit simple growth models, such as log-linear trends. Using this approach, over the period 1974-75 to 2003-04, trend growth in the agriculture sector's MFP is estimated to have averaged around 2.3 per cent a year. This compares with trend MFP annual growth for the market sector of 1.0 per cent a year over the period.[2]

---

2 These estimates are calculated by regressing the log of the data against a constant and a time trend using original (unadjusted) data. This differs from ABS trend data, which are produced by applying a Henderson smoothing algorithm to the original data series (ABS Cat. no. 5216.0).

Peak-to-peak trends are another way of isolating seasonal variations and other random factors in order to make a more meaningful comparison of productivity over time. Peak-to-peak analysis (see appendix D) shows that MFP in Australian agriculture:

- declined at an annual average rate of 0.8 per cent between the 1978-79 and 1983-84 peaks;
- increased by 1.3 per cent a year in the decade between 1983-84 and the pre-drought peak of 1993-94;
- increased by 4.1 per cent a year between 1993-94 and the pre-drought peak of 2001-02; and
- increased by 1.8 per cent a year between 1978-79 and 2001-02 (figure 6.2).

These results confirm the visual observation that MFP in the Australian agricultural sector was relatively subdued between the mid-1970s and the late-1980s, followed by a strong productivity surge during the 1990's. In trend terms, MFP increased at an annual average rate of 1.3 per cent between 1974-75 and 1989-90 and 3.7 per cent per year between 1989-90 and 2003-04.

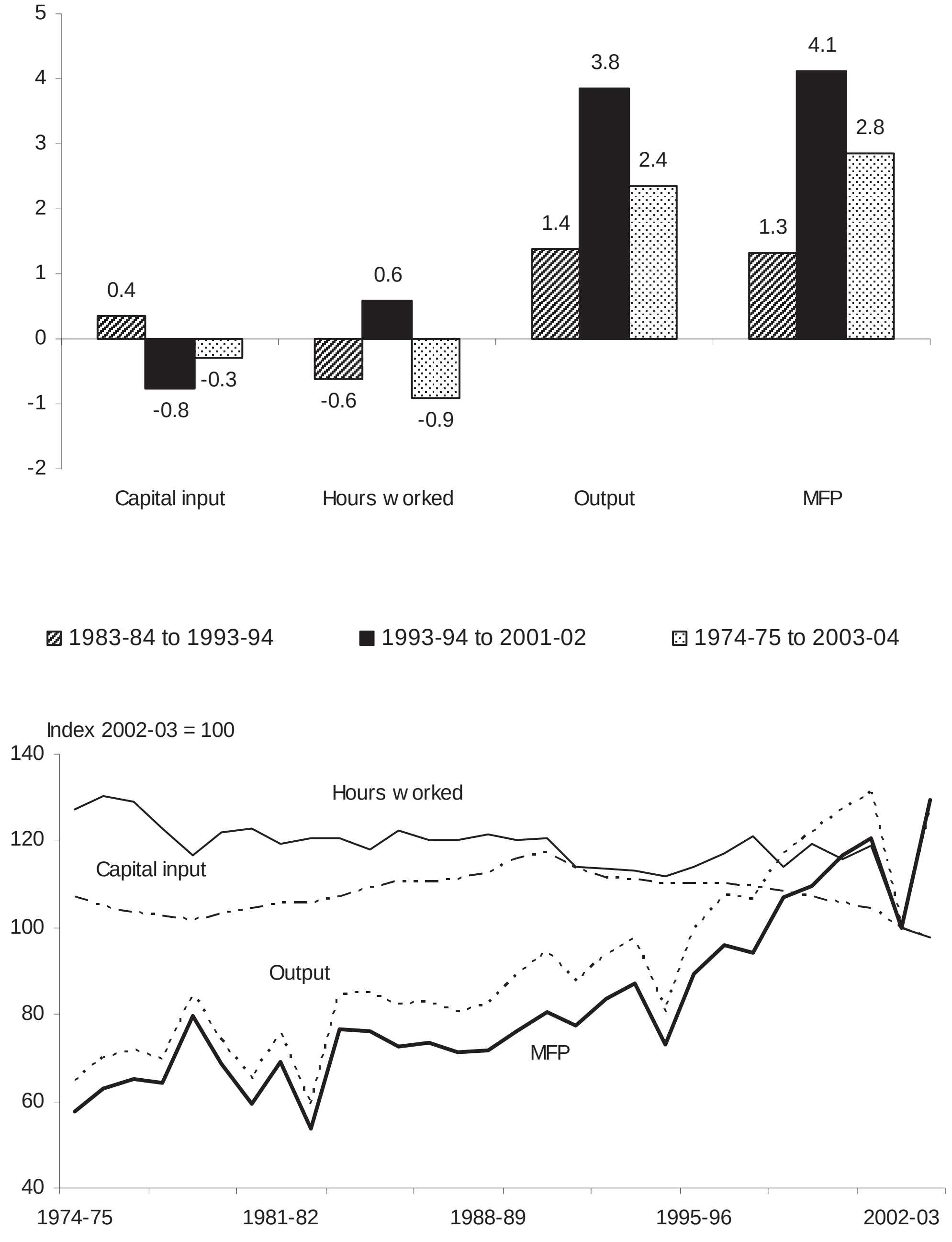
Productivity growth rather than input growth

Over the period 1974-75 to 2003-04, the quantities of both labour and capital inputs used in agriculture declined, while total agricultural output increased at a trend annual average rate of around 2.4 per cent. This means that productivity growth has accounted for the entire increase in output of the agricultural sector over the past thirty years (figure 6.3).

By comparing the actual growth in sectoral output over the period with that which would have been observed had there only been changes in inputs (that is, no MFP growth), it is possible to calculate a productivity 'dividend'. Applying the trend MFP growth rate of 2.3 per cent, it is estimated that this productivity 'dividend' amounted to just over $170 billion over the period (box 6.1).

Figure 6.3 **Growth in inputs, outputs and MFP for agriculture, 1974-75 to 2003-04[ab]**

Per cent a year



a Agriculture, forestry, fishing and hunting. **b** Capital stock estimates are based on gross fixed capital formation data on investment in buildings and structures, machinery and equipment and livestock. The acquisition of non-reproducible tangible assets such as land, subsoil assets and natural timber tracts is not included in gross fixed capital formation (and hence in the capital stock estimates). However, capital costs associated with the extension or development of these assets are included, as are outlays on land reclamation and improvement (ABS 2000).

Data source: PC (2004, Productivity Estimates to 2003-04, December; http://www.pc.gov.au/commission/work/productivity/performance/industry.html).

Box 6.1 **Agricultural output and the productivity 'dividend'**

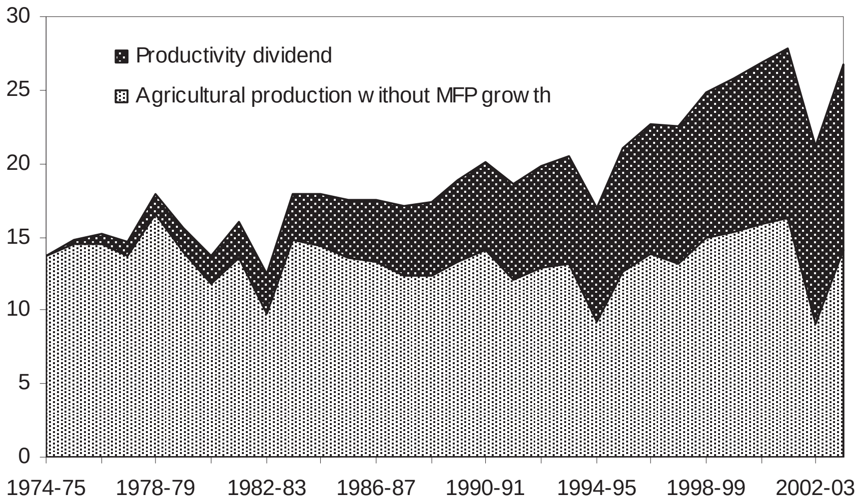
The entire increase in agricultural output over the past three decades can be explained by an increase in MFP. Between 1974-75 and 2003-04, aggregate inputs of capital and labour into agriculture actually declined, while real output increased by 96 per cent. MFP growth accounts for the increase in real agricultural output after accounting for the change in labour and capital inputs (2.8 per cent a year point to point, and 2.3 per cent in trend terms).

Following the methodology of PC (2003), it is possible to estimate the ensuing productivity 'dividend' by comparing the actual growth in agricultural value added achieved between 1974-75 and 2003-04 and that which would have been observed had there been only changes in inputs (that is, no MFP growth).

Applying the trend MFP growth rate of 2.3 per cent, the cumulative annual difference in value added over the period (in constant 2001-02 prices) implies an agricultural productivity 'dividend' of just over $170 billion (figure 6.4).

Figure 6.4 **Impact of MFP growth on agricultural value-added, 1974-75 to 2003-04**

$ billion, constant 2001-02 prices



Data Source: Derived from PC (2004, Productivity Estimates to 2003-04, December, http://www.pc.gov.au /commission/work/productivity/performance/industry.html).

Using the peak to peak periods identified earlier, output growth was stronger in the later period (1993-94 to 2001-02), increasing by around 3.8 per cent per year compared with 1.4 per cent for the decade to 1993-94.

While the number of hours worked in agriculture declined by almost 1 per cent a year over the period 1974-75 to 2003-04, labour inputs declined in the earlier period to 1993-94, but increased slightly in the later period (figure 6.3). Also, as discussed in the previous chapter, the educational attainment of agricultural workers has increased in recent decades, which suggests an increase in the quality per hour worked.

Also evident from figure 6.3 is the notable decline in capital inputs from around the early 1990s — a decline of around 16 per cent over the period 1990-91 to 2003-04. This decline reflects, in part, some of the structural adjustments that have been taking place in the agriculture sector. For example, as average farm size has increased, the ratio of other capital to land capital has fallen. In line with this trend, growth in capital inputs was slightly positive in the earlier period to 1993-94, but negative in the latter (figure 6.3).

In addition, relatively higher capital prices have induced farmers to adopt capital saving production methods such as the sharing of farm capital equipment (contract harvesting).

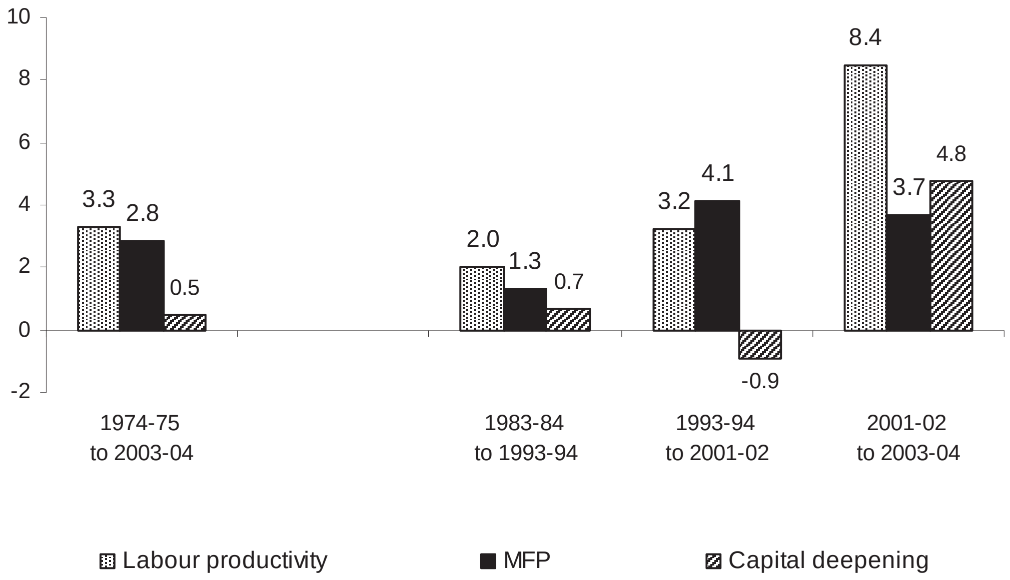
Capital deepening

Labour productivity growth for agriculture was higher than MFP growth over the period 1974-75 to 2003-04, indicating capital deepening (that is, increased quantities of capital per hour worked). Nonetheless, the extent of capital deepening for agriculture over the period was low (0.5 per cent per year) compared with the market sector average (1.1 per cent a year).

As illustrated in figure 6.5, MFP performance was the main influence on labour productivity growth throughout the period. And, over the period 1993-94 to 2001-02, the increase in labour productivity growth was entirely due to increased MFP growth as capital deepening was lower than in the earlier period (and negative, due to declining capital inputs).

Figure 6.5 **Labour productivity, MFP and capital deepening, 1974-75 to 2003-04**

Per cent a year



Data source: PC (2004, Productivity Estimates to 2003-04, December; http://www.pc.gov.au/commission/work/productivity/performance/industry.html).

6.4 Comparisons with other industries

Compared with other sectors of the economy, agricultural MFP growth has been strong. Over the period 1974-75 to 2003-04, MFP growth for agriculture was above all other sectors of the economy. The only industry to record higher MFP growth over the period was communications (table 6.1).

In terms of labour productivity growth, agriculture's performance (3.3 per cent per year over the period) was above the market sector average, but was surpassed by communications and electricity, gas and water. In terms of capital productivity growth, agriculture was the economy's strongest performer — 2.7 per cent per year over the period (table 6.1).

Productivity growth rates, however, provide only part of the story as they do not provide any insight into the relative efficiency with which resources are used. For example, an industry recording a relatively high productivity growth rate may be starting from a relatively low base (that is, have a relatively low level of productivity). Productivity *levels*, therefore, provide an important contextual basis for assessing productivity growth rates.

Table 6.1 **Labour, capital and MFP growth rates by sector and industry for Australia, 1974-75 to 2003-04**

Sector/industry	*Labour productivity*	*Capital productivity*	***Multifactor productivity***
Agriculture	3.3	2.7	2.8
Mining	2.6	-0.8	0.2
Manufacturing	3.2	-1.2	1.6
Services			
Electricity, gas and water	4.1	0.4	1.8
Construction	1.6	-1.6	1.0
Wholesale trade	2.1	-1.0	1.2
Retail trade	1.5	-2.5	0.8
Accommodation, cafes and restaurants	0.0	-2.5	-0.6
Transport and storage	2.8	1.1	2.3
Communications	6.5	1.0	4.2
Finance and insurance	2.2	-3.2	-0.1
Cultural and recreational services	-0.5	-3.1	-1.6
Market sector	2.2	-0.7	1.1

Source: PC (2004, Productivity Estimates to 2003-04, December; http://www.pc.gov.au/commission/work/productivity/performance/industry.html).

Labour and capital productivity levels presented in table 6.2 show that there is considerable variability between industries in output per hour worked and capital employed. Differences in productivity levels between the different industries should not, however, come as any surprise as these levels are really just the inverse of labour and capital intensities. For example, if an industry is labour intensive, its ratio of output to labour is likely to be relatively low. Just as factor intensities vary between industries, so too do partial or single factor productivity levels.

Over the three year period 2001-02 to 2003-04, farmers produced, on average around $29 of output per hour. This was lower than the average for the economy as a whole ($38.50), and for most service industries — the only service industries to record lower levels of output per hour were retail trade, accommodation, cafes and restaurants and personal and other services.

Agriculture's level of capital productivity — $43 of output for every $100 of capital employed — was slightly below that for the market sector as a whole, but higher than electricity, gas and water, transport and storage, mining, communications and accommodation, cafes and restaurants.

Table 6.2 **Levels of labour and capital productivity[a] by sector and industry for Australia**

Average three years ended 2003-04, constant 2002-03 prices

Sector/industry	*Labour productivity* ($ of output per hour worked)	*Capital productivity* ($ of output per $100 of capital)
Agriculture	29.2	42.9
Mining	165.4	25.6
Manufacturing	37.7	79.9
Services	36.5	47.9
Electricity, gas and water	119.9	13.2
Construction	30.5	168.3
Wholesale trade	44.7	111.2
Retail trade	18.0	87.7
Accommodation, cafes and restaurants	20.7	39.7
Transport and storage	43.4	22.0
Communications	61.5	29.8
Finance and insurance	88.9	80.8
Personal and other services	27.4	87.5
Market sector	38.5	47.9

[a] Capital productivity is estimated by dividing output by end-year net capital stock (constant 2002-03 prices) averaged over three years.

Sources: ABS (Cat nos: 5204.0, 6203.0).

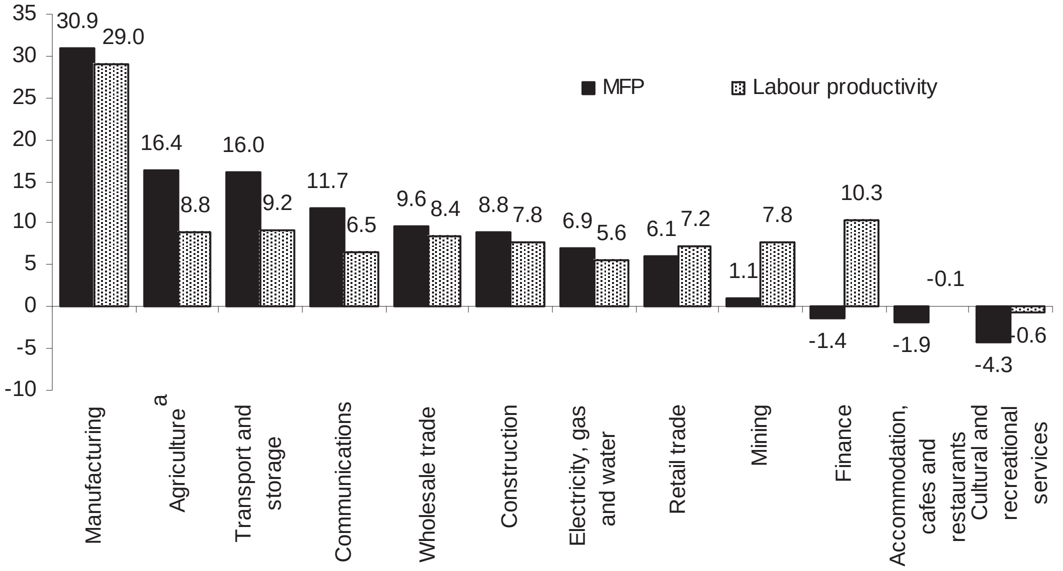
Contribution to productivity growth

The contribution of an industry to market sector productivity growth depends on the industry's growth performance and its share of market sector output. Over the period 1974-75 and 2003-04, agriculture, forestry and fishing contributed 8.8 per cent of market sector labour productivity growth — this was above the sector's value adding share of the market sector (6.7 per cent), and reflects relatively high labour productivity growth in agriculture over the period (figure 6.6).

Agriculture was also a strong contributor to MFP growth over the period 1974-75 to 2003-04, accounting for around 16.4 per cent of market sector MFP growth, or more than double it's value-added share. Indeed, agriculture was the second highest contributor of the twelve market sector industry divisions after manufacturing (31 per cent of MFP growth) over the period.

Figure 6.6 **Industry contributions to productivity growth, 1974-75 to 2003-04**

Per cent



a Agriculture, forestry, fishing and hunting.

Data source: PC (2004, Productivity Estimates to 2003-04, December, http://www.pc.gov.au/commission/work/productivity/performance/industry.html).

With agriculture accounting for around 5-6 per cent of the market sector, changes in agricultural MFP can have a significant effect on aggregate productivity growth. For example, in the 2002-03 drought, agricultural MFP declined by around 17 per cent which in turn, reduced aggregate MFP growth by around one percentage point (around half of market MFP growth) in that year. Similarly, agricultural MFP rebounded in 2003-04 by almost 30 per cent — adding over one percentage point to market sector MFP growth.

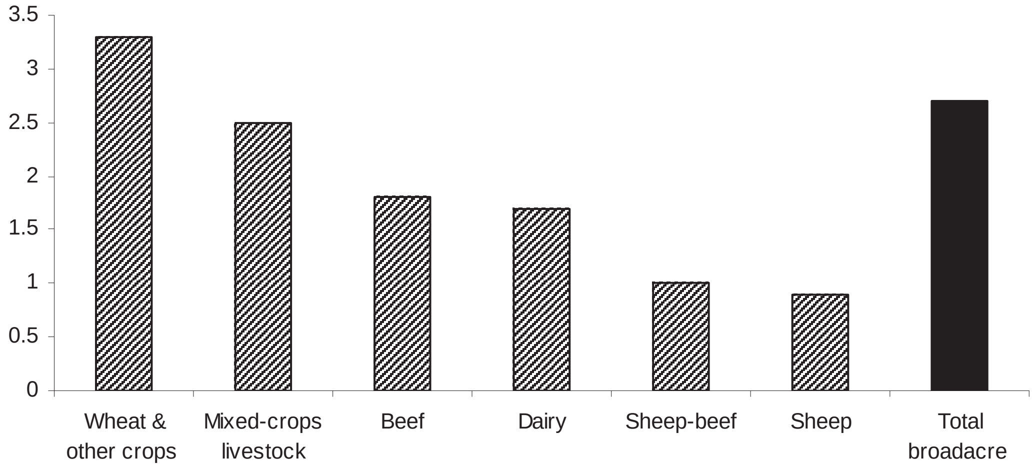
6.5 Productivity trends within agriculture

Productivity growth is far from uniform within the agricultural sector. According to ABARE estimates[3], the cropping industries (wheat, barley, oats, grain sorghum, oilseeds and other crops) have outperformed the livestock industries (sheep, beef and dairy) since the late 1970s.

3 The data used for ABARE's productivity estimates are from ABARE's annual surveys of broadacre industries. The inputs used by ABARE to calculate MFP growth are capital (including land), livestock purchases, labour, materials, and services. Output consists of four main groups, crops, livestock sales, wool and other farm income.

Over the period 1977-78 to 2001-02, MFP on Australian grain farms increased, on average, by around 3.3 per cent per year. Mixed crops/livestock recorded the next highest growth of 2.5 per cent a year over the same period. Beef and dairy farms achieved productivity growth of 1.8 and 1.7 respectively, whereas productivity growth in the sheep industry was considerably lower at 0.9 per cent a year (figure 6.7).

Figure 6.7 **Broadacre productivity growth, by industry, 1977-78 to 2001-02**
Annual growth, per cent



Data source: ABARE Farm Surveys.

The relatively high productivity growth rate achieved in the cropping industry coincided with a decline of around 40 per cent in the number of grain producers and a doubling in the area sown to grains. The average area operated per farm also increased by 50 per cent and there was increased specialisation in grain production (Hooper et al. 2004).

The development of a wider range of planting options in recent decades, both in terms of crop types and varieties, has given farmers increased flexibility in terms of rotation strategies that has had a positive influence on disease control, soil fertility and labour utilisation. As Alexander and Kokic (2005, pp. 5-6) put it:

> Making use of a range of crops can reduce the risk of total crop failure, provide more options for farmers to respond to changes in relative prices, and have a positive effect on disease control and soil fertility. The rotation of crops can also result in more efficient use of resources, such as labour, by spreading the workload more evenly over the year.

Changes in livestock, pasture and stubble management have also allowed the average grains industry producer to increase sheep and cattle numbers. Pasture rotations play an important part in the cropping cycle as they can improve soil fertility, texture and yield and also assist in the control of disease, insects and weeds (Alexander and Kokic 2005).

The relatively high productivity growth recorded by the grains industry was achieved in the face of fierce competition on international markets. The terms of trade facing Australian grain farmers declined by 2.6 per cent a year over the period 1977-78 to 2001-02 (a greater rate of decline than that faced by other agricultural industries), although the productivity gains achieved in the industry, on average, more than offset the negative effects of the declining terms of trade (table 6.3).

Table 6.3 **Average annual MFP growth and terms of trade, selected agricultural industries, 1977-78 to 2001-02**

Per cent

	Outputs	*Inputs*	*Productivity*	*Terms of trade*
Sheep specialists	1.2	0.3	0.9	-2.1
Sheep-beef	0.6	-0.4	1.0	-1.6
Sheep-crops	4.2	1.7	2.5	-2.5
Beef specialists	1.8	-0.1	1.8	-1.4
Beef-crops	2.6	0.2	2.4	-2.4
Crop specialists	4.8	1.5	3.3	-2.6
Dairy[a]	4.6	2.9	1.7	-1.1

[a] The data for dairy cover the period 1978-79 to 2001-02.

Source: ABARE (2004a).

Productivity gains recorded for beef specialists and beef-crop farms also, on average, offset the negative effects of declining terms of trade (table 6.3). And, according to ABARE, productivity growth on beef specialist and beef-crop farms increased in the decade to 2001-02, compared with the decade to 1989-90.

In contrast, the relatively low productivity growth amongst farms raising sheep and sheep-beef over the 25 year period has been insufficient, on average, to offset declines in their terms of trade. This may be partly explained by less significant changes in technology and production methods in these industries relative to cropping. As Knopke, et al. (1995, p. 490) note:

> Although there have been improvements in beef and sheep genetic material and in livestock health products, their impact has been less than that of advances in cropping technology. The handling of livestock (particularly sheep shearing and the handling of the wool clip) remains one of the more labour intensive activities in the broadacre sector.

Sheep producers who have diversified into prime lamb production, however, have recorded average annual growth in MFP of 1.6 per cent over the period 1988-89 to 2001-02. This was more than sufficient to offset the average annual decline of 0.7 per cent in their terms of trade (ABARE 2004a).

Changes in the dairy industry over the last two decades have seen Australia's milk production more than double and annual yields per cow increase by more than 70 per cent. MFP growth for the industry is estimated to have been just under 2 per cent a year over the period 1978-79 to 2001-02, with MFP growth being slower in the decade to 2001-02.

One of the explanations given by ABARE for the slowing of productivity growth in the later decade is that increases in grain feeding have not been matched by increases in milk output. Another is that the more easily exploited productivity improvements resulting from technology changes — such as adoption of larger and more efficient dairies or the introduction of herd recording — may have been largely accomplished and that further productivity improvements may be more difficult to achieve and depend more critically on management skills. Box 6.2 profiles productivity growth in the dairy industry.

Productivity growth estimates for agricultural industries, other than broadacre and dairy, are not readily available. Keogh (2004, p. 7), however, suggests that because of the technology being employed in some of the more intensive agricultural industries, productivity growth may well be higher in some of these industries than that recorded in the grains industry:

> Technology seems destined to produce even faster productivity gains in the more intensive agricultural enterprises, especially poultry meat, pork, dairy and horticulture. Many farmers in these industries already have high levels of investment in technology, which is driving high productivity growth. (Keogh 2004, p. 14)

Productivity growth differences between farms

Farm size appears to have an influence on productivity growth with larger farms typically achieving higher productivity growth than smaller farms. Research by ABARE (Alexander and Kokic 2005), for example, shows that over the period 1977-78 to 1998-99, large farms in the cropping industry achieved MFP growth of around 3.5 per cent per year; this was considerably higher than that achieved on medium (2.7 per cent) and smaller cropping farms (2.4 per cent) .

Box 6.2 **Productivity improvements in the dairy industry**

Over the last two decades, Australian dairy farmers have made many changes to farm management practices and have adopted a range of new technologies. Examples of some of the changes include:

- greater use of supplementary feeding — the feeding of concentrates and grains to boost milk production or fill seasonal feed shortages;
- soil testing and, as a result, changed fertiliser management;
- improved herd management;
- artificial insemination;
- greater use of computers. ABARE survey data indicate that dairy farmers initially used computers for budgeting and financial records but incorporated computerised management of breeding and milk production records as their skills developed; and
- substantial investment to incorporate advances in dairy shed technology, including herringbone swingover and rotary dairies.

The last two decades have also seen:

- the number of dairy farms more than halved, from 22 000 in 1980 to less than 10 000 in 2004; and
- the average herd size increase from 85 cows in 1980, to around 210 in 2003-04.

The outcome of such changes has been significant gains in labour productivity and increases in milk yields per cow and per farm. Over the period 1980 to 2003-04:

- the average annual yield per cow increased from 2 850 to 4 900 litres; and
- the average milk production per farm increased from 247 000 to 1 048 000 litres.

MFP growth over the decade to 2001-02 was around 1.5 per cent a year. This compares with a MFP growth rate of around 2 per cent a year for the period 1977-78 to 1998-99. Only dairy farms in New South Wales and South Australia managed to lift their productivity performance compared with a decade earlier. MFP also increased at a faster average rate in New South Wales, South Australia, Western Australia and Tasmania than that for Australia.

Sources: Hogan et al. (2004); Dairy Australia (www.dairyaustralia.com.au); Garnaut and Rasheed (1998); ABARE 2004c.

Additionally, ABARE found that unit costs of sowing crops declined as farm productivity increased and sowing costs declined as the size of the farm operations increased, indicating that there are economies of size operating in the grains industry (Alexander and Kokic 2005).

Productivity growth has also been closely related to size in the beef and sheep industries. In the beef industry, over the period 1977-78 to 2001-02, the largest third of farms enjoyed strong productivity growth (2.2 per cent a year), while the smaller two-thirds recorded little or no growth. Similarly, large prime lamb producers recorded MFP growth of 1.4 per cent compared with 0.8 per cent for small prime lamb producers (ABARE 2004a,e).

The lumpy nature of investment in many of the new technologies, such as advanced mechanical harvesters, automated feeding systems and milking robots, means that they are often better suited to larger scale farming. Also, a larger capital base means that larger farms are often better placed to finance new developments in management and farming practices. As Hooper et al. (2002, pp. 498-499) note:

> Larger farms, particularly in the cropping and to a lesser extent in the broadacre livestock industries, have generally been able to capture more benefits from new technologies and have achieved much higher growth in total factor productivity over the past two decades. Higher productivity growth for larger farms has been very important in improving the financial performance of large farms relative to that of smaller farms.

There has also been significant variation in farm productivity growth by states and regions across Australia. This is not surprising given that land quality, climate and enterprise mix vary across the states and regions.

ABARE's mapping of trends in broadacre productivity growth over the twenty year period 1977-78 to 2001-02 found that productivity growth was higher on broadacre farms in Western Australia, South Australia and New South Wales than in Victoria and Queensland. Productivity growth on dairy farms over the period 1978-79 to 2001-02 was higher in Tasmania, Western Australia and New South Wales than in the other states.

The distribution of broadacre industries appears to be a key factor contributing to observed differences in productivity growth across regions. For example, the wheat-sheep zone, where cropping activities are concentrated, recorded the largest productivity improvements while regions where livestock activities dominated recorded lower productivity gains. The areas of lowest productivity growth were concentrated in the high rainfall zones where the combination of livestock focused activities and small farm size are likely to have contributed to the relatively lower productivity gains (Ha and Chapman 2000).

Another factor contributing to variations in productivity across regions is resource quality (for example, the inherent productive capacity of the land or the presence of land degradation). The productive capacity of a particular farm or region is dependent, to some extent, on the quality of the land — which should be reflected in its value. ABARE analysis of farm survey data shows positive relationships between productivity, land values and rates of return to capital, indicating that measures of productivity are influenced by resource quality issues.

6.6 Drivers of productivity growth in agriculture

Productivity improvements in agriculture reflect a range of mechanisms and underlying influences. As outlined in IC (1997), there are three main 'proximate' mechanisms of productivity growth:

- new knowledge or technology that has brought about new ways of doing things that create more output from a given amount of inputs;
- better organisation of production within farms and between agricultural industries (improving productivity within the bounds of existing knowledge); and
- incidental effects that arise, not through the active pursuit of improved productivity, but as a by-product of other developments.

The following sub-sections briefly discuss these mechanisms and some of the underlying influences.

New knowledge or technology

A key source of productivity growth in agriculture has been the generation of new knowledge or technology. New knowledge introduces new ways of doing things that result in more output per unit of input.

Institutionalised agricultural research and development, as well as farmers own experimentation, have been important factors in the creation of new knowledge and technical advances in agriculture. The OECD (1995, p. 24), for example, observed that 'there is growing agreement that R&D is a crucial determinant of agricultural productivity'.

A Commission inquiry into Research and Development (IC 1995) also found with respect to R&D expenditures, the agriculture sector differs from other sectors of the Australian economy in that there are very low levels of internally generated R&D. That said, the rural R&D corporations and councils which sponsor R&D for the benefit of the agricultural sector tend to be partly funded by industry contributions together with government contributions. Much of the R&D sponsored by these organisations is undertaken by public sector researchers such as CSIRO and state departments of agriculture.

Some examples of technological advances that have contributed to productivity improvements in the agriculture sector include:

- the development of more sophisticated farm machinery and equipment. For example, the development of mechanical harvesting of wine grapes allowed broadacre style harvesting, pruning and spraying of vines yielding significant reductions in the cost of harvesting grapes. Precision agriculture has improved the accuracy of machinery and equipment, and farmers' understanding of their soil. This has enabled farmers to better tailor water, fertiliser, herbicide and pesticide treatments to their production requirements, often reducing the quantities of inputs required and having positive environmental impacts;
- the development of improved herbicides, fertilisers and other chemicals that have enhanced yields (either directly or indirectly through the control of pests and disease); and
- genetic modification involving the manipulation of the genetic structure of living organisms (more directly than through conventional plant and animal breeding) has created opportunities for raising the productive potential of plants and animals by, for example, enhancing their resilience. One example is the commercial release of an insect resistant cotton (Ingard) in Australia in 1996.

Technological advances, such as precision agriculture and biotechnology, (including genetic modification), also hold the potential for further improvements in agricultural productivity (box 6.3).

One of the explanations for the superior productivity performance of cropping industries (see section 6.5) relates to the significant changes that have occurred in cropping technology over the last few decades. Examples include crop varieties with improved resistance to disease, more effective use of as well as improvements to fertilisers and pesticides and the adoption of minimum till practices. And, while there have been improvements in beef and sheep genetic maintenance and livestock health products, their impact has been less than in cropping (Ha and Chapman 2000). Livestock activities have also tended to remain relatively more labour-intensive activities.

Box 6.3 **Biotechnology and agriculture**

Biotechnology covers a range of research tools that allow scientists to understand and manipulate the genetic make-up of plants, animals and other living organisms. In agriculture this includes genomics, marker-assisted selection, genetic engineering and many other tools that complement each other and conventional breeding approaches.

Biotechnology enables researchers to characterise plants and animals at the genomic level, so the specific genes responsible for a desirable trait can be targeted in breeding and conservation programmes. In contrast, conventional breeding relies on the physical appearance of a specimen and this is often an imperfect guide to its value in breeding.

Commercial use of biotechnology to produce genetically modified (GM) crop varieties first emerged in the mid 1990s. The four most widely grown GM crop plants across the world are soybean, maize, cotton and canola. The estimated global value of GM crops in 2003 was over United States $4.5 billion.

There are currently two GM plants grown commercially in Australia – cotton and blue carnations. While GM carnations are grown on a very small scale, GM cotton dominates Australia's cotton crop.

The benefits to farmers from GM crops include higher yields and profits. There are also substantial environmental advantages. For example, there has been a significant drop in pesticide usage in Australia's cotton industry in recent years as the area sown to GM cotton varieties has increased.

As ABARE (Abdalla et al. 2003, p. 111) has stated:

> The application of biotechnology techniques within the agriculture sector can potentially improve food security by raising crop tolerance to adverse weather and soil conditions, by enhancing adaptability of crops to different climates and by improving yields, pest resistance and nutrition, particularly of stable food crops. Over the past decade, the application of biotechnology to the problems in world agriculture has yielded significant productivity gains to producers. With advancements in GM technologies and as market acceptance and availability of GM products increases, these benefits are expected to increase.

Sources: Raney (2004), Higgins and Constable (2004), Abdalla et al. (2003).

Better organisation of production

Productivity growth in agriculture has also come about as a result of the better organisation of production. Key influences in this context have been pressures from competing overseas producers, the enabling effects of new process technologies such as IT and the internet, as well as changes to various institutional and regulatory arrangements (including reforms to statutory marketing arrangements for several industries, see box 3.4).

Australian farmers have responded to these influences by making better use of available technologies and management practices. One example is farmers making use of machinery pooling or the use of contractors rather than tying up capital in plant and equipment which is poorly utilised. Another is dairy farmers making greater use of the feeding of concentrates and grains to boost milk production.

Australian farmers are now better educated than they were two decades ago (chapter 5). Education and training can have an important influence on the ability of farmers to adopt new technology and the way they utilise existing technologies and management practices. In this context, Australian farmers have made greater use of information technology and the internet (box 6.4). An increasing number of farmers, for example, are using the internet and information technology to monitor international market trends, communicate and interact with suppliers throughout the agriculture supply chain, access weather forecasts and use satellite imagery in developing farm plans (Corish 2004). ABARE survey data also shows that while dairy farmers initially used computers for budgeting and financial records, they are increasingly adopting computerised management of breeding and milk production records as their skills develop.

Microeconomic reforms have also resulted in a shift of resources to more productive activities. Water reforms, for example, have seen some shift away from crops which use a lot of water for relatively poor returns towards higher value plantation horticultural enterprises (see, for example, Peterson et al. 2004). As Keogh (2004, pp. 14-15) observed:

> The enhancement of the tradability of water access rights, as is proposed under the National Water Initiative currently being negotiated between Australian governments, should also enhance productivity gains in industries such as horticulture. It is likely that this change will accelerate the movement of irrigation water away from broadacre crop use, to some of the higher-value plantation horticulture enterprises; a trend that is already evident in Victoria and South Australia. The increasing capital value of water access rights will add further impetus to productivity gains in these industries.

The Commission’s inquiry into *Native Vegetation and Biodiversity Regulation*, found that regulations in these areas were not as effective as they might be and, in some cases, were imposing significant and unnecessary costs on farmers. Clearing controls, for example, were found to be preventing the expansion of agricultural activities, preventing changes in land use and the adoption of new technologies and inhibiting management of weeds and vermin. Changes to these regulations, as recommended by the Commission, can be expected to improve incentives for farmers to adopt sustainable farm and environmental management practices and thereby enhance the potential for future productivity gains (PC 2004b).

Box 6.4 **Computer technology and farming**

Australian farmers are making greater use of computer technology and the Internet to assist them with their business operations and to gain relevant information.

Over the period March 1998 to June 2002, the proportion of farms with access to a computer and the Internet increased by 22 and 37 percentage points respectively. By June 2002, 62 per cent of Australian farms had access to a computer and around 48 per cent had access to the Internet.

Of the farms with access to a computer in 2002, more than four in five used it as part of their business operations. Nine in 10 farms with access to the Internet used it as part of their business operations.

Email is the most common Internet activity undertaken by farmers (37 per cent of all farms), followed by obtaining weather information (31 per cent). Around 10 per cent of Australian farms purchased or ordered goods or services via the Internet in 2002.

In 2002, the cotton industry reported the highest use of computers — 90 per cent of farms. Other industries with relatively high use of computers included plant nurseries (69 per cent), poultry farming (meat, 63 per cent) and grain growing (67 per cent). Beef cattle farming recorded the lowest use of computers (38 per cent).

The cotton industry also had the highest use of the Internet (87 per cent) and beef cattle farming the lowest (30 per cent).

ABS data for 2002 indicates a strong relationship between farm size (as measured by the estimated value of agricultural output), and the use of a computer and the Internet. For all broad industries, a 50 per cent Internet usage rate was not achieved until the EVAO range of $150 000- $249 999, except for dairy cattle farming where this usage rate was achieved by farms with an EVAO range of $500 000-$999 999.

Source: ABS (Cat no. 8150.0).

Incidental effects

Productivity growth within the agricultural sector has also been affected by structural changes such as increases in farm size, shifts in the enterprise mix of the agricultural sector and the exit of lower performing farmers.

As discussed in chapter 3, farms have increased in size across most agricultural industries as a result of low-performing farmers leaving the sector and farm amalgamations. Larger farms are generally able to capture more of the benefits from new technologies. And, as farm size grows, output can often be increased over a range without requiring extra units of capital, allowing overhead costs to be spread over more units of output. For example, within limits, a dairy herd can be expanded without the need to expand the milking shed or purchase additional capital equipment.

Also, because productivity varies among agricultural industries, changes in the composition of the sector affects the sector's productivity. Productivity in the wool industry, for example, has been relatively modest and this industry has been declining in importance over the last two decades. The cropping industry, on the other hand, has experienced high productivity growth and has also expanded rapidly in terms of output and farm numbers. These structural changes have acted to bolster the productivity performance of the sector over time.

6.7 International comparisons

International comparisons of productivity are another way of benchmarking the performance of Australian agriculture. The international competitiveness of Australian agriculture is also shaped by its productivity performance.

OECD countries provide a reasonable basis for comparison of Australia's productivity performance given their broadly similar stage of economic development. There are, nevertheless, some important differences among these countries that need to be recognised when making comparisons. More specifically, differences in productivity levels and growth may reflect different resource endowments, different price environments, differences between countries in exploitation of 'catch-up' opportunities, the use of different technologies and differing institutional and regulatory arrangements.

And, while indicative, comparative measures are relatively imprecise since measurement problems (such as issues of data comparability and different industry mixes) are exacerbated in international comparisons. Caution, therefore, needs to be taken in interpreting differences in productivity performance of agricultural industries across countries.

Comparison of growth rates

Bearing the above caveats in mind, it appears that growth in Australian agricultural labour productivity over the last two decades has been relatively low. Using data contained in the OECD's STAN Industrial Database and ABS data for Australia, it appears that over the period 1981-2001, Australia's agricultural labour productivity growth has been lower than that achieved in the United States and many European countries. The only countries to record lower labour productivity growth for agriculture over this period were Sweden, Greece and the United Kingdom (table 6.4).

Table 6.4 **Agricultural labour productivity growth rates for selected countries**

Trend annual growth rates

Country	*1981-91*	*1991-2001*	*1981-2001*
Australia[a]	**1.8**	**4.7**	**2.8**
Austria	2.9	9.1	5.7
Belgium	3.9	4.2	4.7
Canada	3.8	2.2	3.0
France	5.8	6.6	6.7
Finland	4.0	4.8	4.5
EU-15	5.2	4.3	5.1
Denmark	8.2	8.5	8.3
Greece	3.0	1.3	2.4
United States	5.2	5.5	4.8
Ireland	4.5	1.4	3.7
United Kingdom	2.0	2.4	2.6
Portugal	6.6	2.8	6.0
Sweden	5.0	-1.5	1.1
Luxembourg	3.7	8.0	6.6
Spain	7.1	1.3	4.2

a The estimates for Australia are based on ABS data as the OECD's STAN Industrial Database currently does not have data for Australia.

Sources: OECD (2004) STAN Industrial Database; ABS (Cat. no. 6203.0).

In the decade to 1991, Australia recorded the lowest growth in agricultural labour productivity for the group of selected countries. However, in the decade to 2001, Australia's relative position improved, with Australia recording a higher labour productivity growth rate for agriculture than Belgium, Canada, Greece, Ireland, the United Kingdom, Portugal, Sweden and Spain.

In contrast, a recent study by Coelli and Prasada Rao[4] (2003), which compares total factor productivity (TFP) (equivalent to MFP) growth in agriculture across the top 93 agricultural producers in the world (accounting for around 97 per cent of the world's agriculture), suggests that Australia's performance has been relatively strong compared with other OECD countries over the last two decades. The study, which uses data from the Food and Agricultural Organization covering the period 1980 to 2000, shows that Australia's MFP growth was similar to that recorded for the United States. The only other OECD countries to record a higher rate of MFP growth for agriculture over the period were Canada and Denmark.

4 Coelli and Prasada Rao measure TFP using the Malmquist index method. This approach uses data envelopment analysis methods to construct a piece-wise linear production frontier for each year in the sample. The study is based on data from the AGROSTAT system of the Statistics Division of the Food and Agricultural Organization.

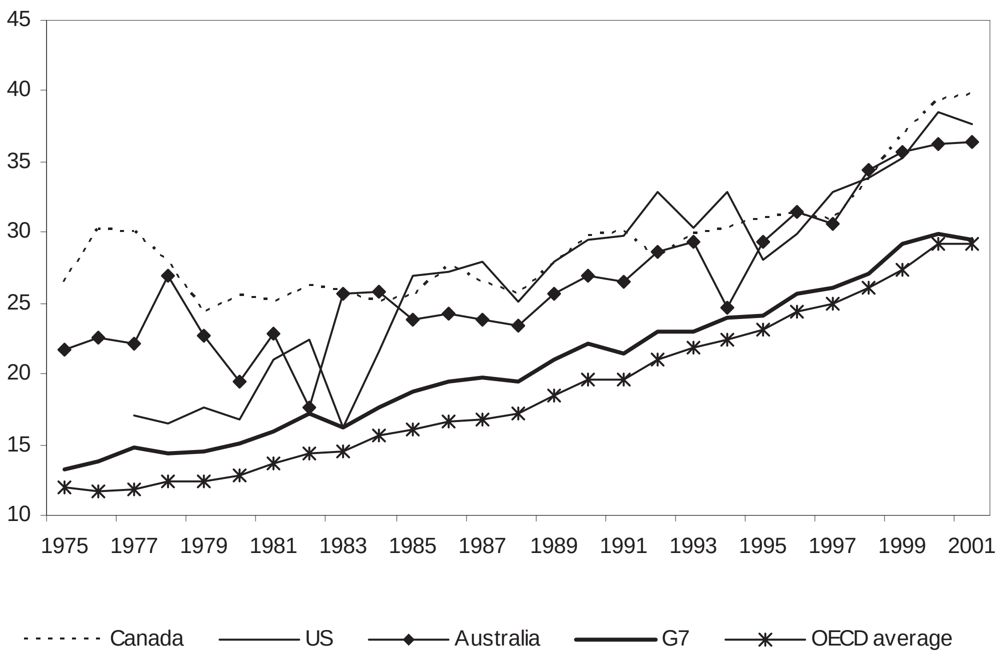
Comparisons of the levels of productivity

Whilst comparisons of growth rates provide a benchmark for the relative performance of Australian agricultural over time, it is also revealing to consider absolute productivity levels between countries. These, together with prices and exchange rates, determine the international competitiveness of Australian agriculture. Comparing productivity levels across countries requires value added to be expressed in a common currency. Exchange rates based on purchasing power parities (PPP) are usually used for this purpose.

Estimates of PPP-based labour productivity levels (output per person employed) between countries indicate that, in 1980, Australian agricultural labour productivity was below the Canadian level, but around 30 per cent above the United States level and around 50 per cent above the OECD average (figure 6.8). While measurement errors may affect comparisons, the data also suggest that, by 2001, Australia had slipped slightly behind the United States but continued to remain well above the OECD average (by around 30 per cent).

Figure 6.8 **Comparative levels of agricultural labour productivity, selected countries, 1975 to 2001**

GDP per person employed (US$'000 PPP)



Data source: PC estimates based on OECD (2004) STAN Industrial Database.

Concluding comment

Compared with other OECD countries, it would appear that Australia has experienced relatively high MFP growth over the last two decades.

That said, as noted, there is considerable variation between high and low productivity performing farms within the Australian agricultural sector. While such variations reflect to some extent differences in climate and soil quality between farms (factors outside the control of farmers), they also reflect differences in the uptake of best practice technologies and farm management techniques. The latter difference points to scope for lifting the productivity performance of the sector as well as the desirability of undertaking research to better understand the drivers of performance differences between farms.

A Input-output links for agricultural industries

Table A.1 **Disposition of output shares by demand category[a], 1998-99**

	Intermediate inputs	*Private consumption*	*Government consumption*	*Investment*	*Exports*
Commercial fishing	37.0	41.7	4.1	0.0	17.2
Forestry & logging	78.8	1.5	11.4	2.2	6.1
Services to agriculture	49.7	1.0	3.4	0.0	45.9
Other agriculture	60.3	30.8	0.0	0.0	8.9
Poultry	75.0	24.7	0.0	0.0	0.2
Pigs	99.1	0.7	0.0	0.0	0.2
Dairy cattle	83.8	0.1	0.0	16.2	0.0
Beef cattle	79.3	0.7	0.0	13.5	6.4
Grains	35.8	0.0	0.0	0.0	64.2
Sheep	50.2	0.8	0.0	3.8	45.3
Agriculture	59.1	12.7	0.9	3.6	23.6
Mining	39.9	0.8	0.0	0.3	59.0
Manufacturing	53.5	21.6	1.1	6.4	17.5
Services	39.7	31.2	13.5	12.1	3.5

a Data are based on input-output industries and exclude changes in inventories.

Source: ABS (Cat. no. 5209.0).

Table A.2 **Direct requirement coefficients for agricultural and selected manufacturing industries, 1998-99**

Per cent

	These industries provide inputs …								
	Sheep	*Grains*	*Beef cattle*	*Dairy cattle*	*Pigs*	*Poultry*	*Other agric*	*Services to agric*	*Forestry & logging*
… to the output of these industries.									
Sheep	0.0	0.5	0.0	0.0	0.0	0.0	3.0	8.9	0.1
Grains	0.0	9.8	0.0	0.0	0.0	0.0	0.0	2.3	0.0
Beef cattle	0.0	0.6	0.1	0.0	0.0	0.0	3.8	3.9	0.5
Dairy cattle	0.0	1.0	0.1	0.1	0.0	0.0	3.1	3.6	0.2
Pigs	0.0	1.7	0.0	0.0	0.0	0.0	3.7	0.8	0.0
Poultry	0.0	1.4	0.0	0.0	0.0	1.7	0.0	1.0	0.0
Other agric	0.0	0.2	0.0	0.0	0.0	0.0	2.3	4.6	0.4
Services to agric	0.1	0.0	0.0	0.0	0.0	0.0	36.3	0.7	0.0
Forestry & logging	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	11.8
Commercial fishing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat/meat products	4.7	0.0	27.4	0.0	4.2	7.0	0.0	0.9	0.0
Dairy products	0.0	0.0	0.0	36.1	0.0	0.0	0.2	0.0	0.0
Fruit/veg. products	0.0	1.1	0.0	0.0	0.0	0.0	13.4	0.0	0.0
Oils & fats	0.0	0.4	0.0	0.0	0.0	0.0	0.7	0.4	0.0
Flour mill products	0.0	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bakery products	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Confectionery	0.0	0.3	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Other food products	0.0	4.2	0.0	0.0	0.0	0.0	12.5	0.0	0.0
Soft drinks/cordials	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
Beer & malt	0.0	9.9	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Wine & spirits	0.0	1.7	0.0	0.0	0.0	0.0	24.6	0.0	0.0
Tobacco products	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
Textile fibres/fabrics	32.7	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0
Leather products	3.8	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Sawmill products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4
Other wood prods	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
Pulp & paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7

Source: ABS (Cat. no. 5209.0).

B Trade data

Intra-industry trade

The usual measure of intra-industry trade is the Grubel-Lloyd index based on comparing export and import flows within reasonably disaggregated trade classifications.

For the i[th] trade classification, the value of intra-industry trade (VIIT) is:

$$\mathrm{VIIT_i} = (\mathrm{X_i} + \mathrm{M_i}) - \left|\mathrm{X_i} - \mathrm{M_i}\right|$$

While the Grubel-Lloyd index (IIT) is:

$$IIT_i = \left[\frac{(X_i + M_i) - \left|X_i - M_i\right|}{(X_i + M_i)}\right] \times 100$$

where *X* are exports and *M* are imports of good *i*.

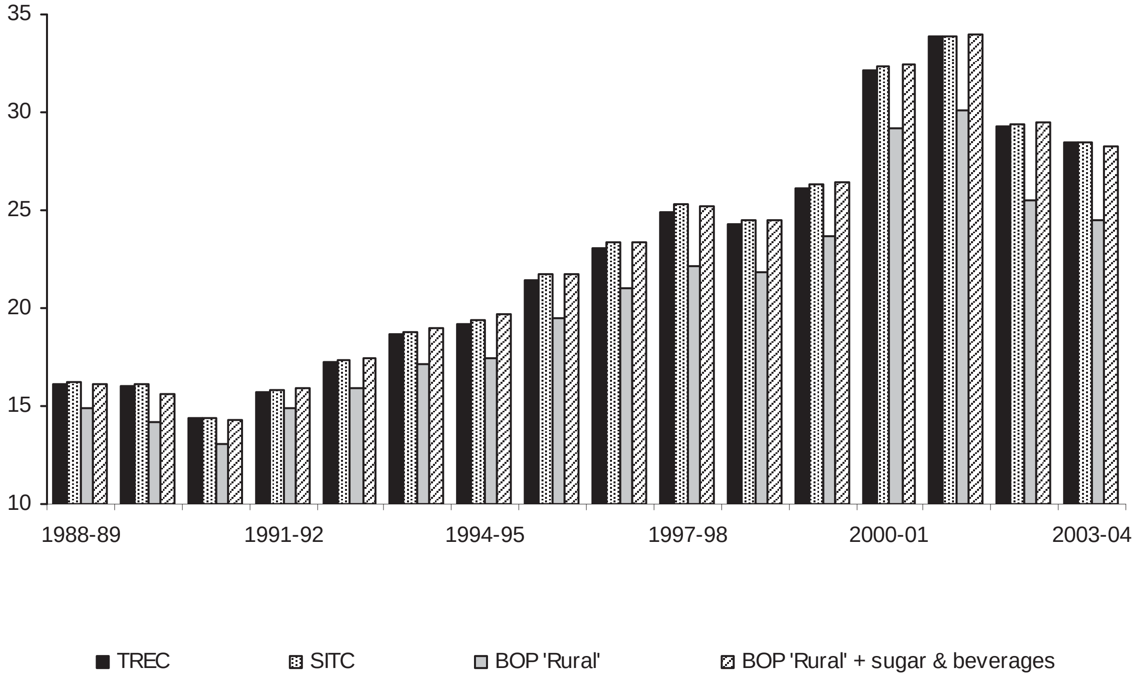
This implies that if exports or imports are zero, IIT will be zero. If exports and imports are exactly matched, then the measure will be equal to 100. So, the measure is bounded by 0 and 100. The overall intra-industry trade index for agriculture in Australia is calculated as a weighted average of the individual intra-industry trade measures:

$$IIT = \sum_{i=1}^{n} \left\{ \frac{(X_i + M_i)}{\sum_{i=1}^{n} (X_i + M_i)} \frac{(X_i + M_i) - \left|X_i - M_i\right|}{(X_i + M_i)} \right\} \times 100 = \left\{ \frac{\sum_{i=1}^{n} \left((X_i + M_i) - \left|X_i - M_i\right|\right)}{\sum_{i=1}^{n} (X_i + M_i)} \right\} \times 100$$

The resulting index represents the share of total agricultural trade accounted for by intra-industry trade (Grubel and Lloyd 1975).

Figure B.1 **Agricultural exports according to TREC, SITC and BOP[a] classification systems, 1988-89 to 2003-04**

$ billion, current prices



a BOP 'Rural' exports include most agricultural commodities included in the SITC classification with the exception of the 'Non-rural' BOP commodities: 'Beverages' (predominantly wine) and 'Sugar, sugar preparations and honey' (predominantly raw sugar). For this report, beverages and sugar are added to rural exports. Although based on SITC data, BOP estimates are adjusted where necessary for timing, coverage, classification and valuation in order to meet the change of ownership conventions and classification requirements required by BOP international statistical standards. For example, wool exported to stockpile abroad before being sold is excluded from the BOP when shipped, but included when sold.

Data sources: ABS (Cat. nos. 5302.0, 5331.0); DFAT (STARS Database 2005).

Table B.1 **OECD projections of agricultural consumption and production growth rates for OECD and non-OECD countries, 2004 to 2013**

Annual average growth (per cent, volume terms)

	Consumption			*Production*		
	OECD	*Non-OECD*	***Total***	*OECD*	*Non-OECD*	***Total***
Wheat	0.8	1.4	**1.2**	1.5	2.0	**1.8**
Rice	0.8	0.8	**0.8**	1.1	1.3	**1.3**
Coarse grains	0.8	1.8	**1.3**	1.4	1.8	**1.6**
Coarse grains used for feed	1.0	2.1	**1.5**	na	na	**na**
Oilseeds	na	na	**na**	2.5	2.8	**2.7**
Oilseed meal	1.6	3.8	**2.6**	2.2	2.9	**2.6**
Beef	0.4	3.0	**1.5**	0.6	2.8	**1.6**
Pig meat	0.8	2.0	**1.5**	0.8	2.0	**1.5**
Poultry meat	1.7	2.5	**2.0**	1.7	2.1	**1.9**
Butter	0.4	3.3	**2.3**	0.0	3.8	**2.2**
Cheese	1.7	2.8	**2.0**	1.6	3.4	**2.0**
Skim milk powder	0.0	2.3	**1.0**	-0.7	5.6	**0.7**
Whole milk powder	1.7	2.8	**2.6**	1.9	3.4	**2.6**
Vegetable oils	1.7	3.8	**2.9**	2.0	2.9	**3.0**
Sugar	0.5	2.2	**1.8**	0.5	2.2	**1.7**

Source: OECD (2004a).

C Supplementary employment data

This appendix provides additional employment data to support the analysis presented in chapter 5. It includes the following:

- the distribution of agricultural employment and employment in associated manufacturing and services industries by State/Territory and metropolitan/non-metropolitan region; and
- the changing composition of the agriculture workforce, in terms of industry shares, gender, working hours, age and occupation.

Table C.1 **Agricultural employment by state/territory[a], 2003-04**
'000 employed persons

Industry/sector	*NSW*	*VIC*	*QLD*	*WA*	*SA*	*TAS*	*NT*	*ACT*
Agriculture, forestry and fishing	94.1	82.2	85.4	48.2	45.2	16.8	2.3	*0.4
Agriculture	83.2	74.1	76.0	37.5	37.5	10.6	1.4	*0.4
Horticulture and fruit growing	17.8	24.7	24.4	8.3	16.2	2.7	*0.7	*0.1
Grain, sheep and beef cattle	49.2	32.0	36.3	25.0	16.0	5.6	*0.6	*0.2
Dairy cattle	*4.7	9.2	*1.2	*1.2	2.4	*1.0	…	*0.1
Poultry	*3.3	*2.4	*2.4	*0.8	*0.5	*0.4	…	…
Other livestock	*2.5	*3.0	*2.4	*0.8	*1.2	*0.2	…	…
Other crops	*1.2	*0.9	8.0	*0.3	*0.1	*0.2	*0.1	…
Agriculture nec	*4.6	*1.8	*1.5	*1.1	*1.2	*0.6	…	*0.1
Services to agriculture	*5.4	5.6	5.2	6.0	*2.0	*1.0	*0.1	…
Forestry and logging	*3.6	*2.1	*0.3	*1.4	*1.3	3.4	*0.1	…
Commercial fishing	*1.6	*0.6	*3.7	3.3	4.3	1.8	*0.6	…
Agriculture, forestry and fishing nec	*0.6	…	*0.2	…	*0.2	*0.1	*0.2	…

… Indicates industries where employment is either nil or negligible. **a** Data are based on survey information, and so information for Agriculture, Forestry and Fishing subdivisions and groups, or at state and territory level, is less reliable than more aggregate information at division or national level. Estimates with a relative standard error of 25 per cent or greater are preceded by an asterisk (for example, *5.2) to indicate they are subject to high standard errors and should be interpreted with caution.

Source: ABS (Cat no. 6291.0.55.001).

Table C.2 **Agricultural employment in metropolitan[a] and non-metropolitan regions[b], 2001**

ANZSIC class	Metropolitan No. employed	Metropolitan %	Non-Metropolitan No. employed	Non-Metropolitan %	Total No. employed
Shearing services	89	3.1	2823	96.9	2912
Grain-sheep and grain-beef cattle farming	1380	3.5	38 439	96.5	39 819
Grain, sheep and beef cattle farming, undefined	71	3.5	1965	96.5	2036
Sugar cane growing	353	3.6	9501	96.4	9854
Cotton growing	181	5.1	3390	94.9	3571
Sheep-beef cattle farming	935	5.2	17 180	94.8	18 115
Grain growing	997	5.5	17 034	94.5	18 031
Sheep farming	1800	7.5	22 098	92.5	23 898
Dairy cattle farming	2194	7.7	26 311	92.3	28 505
Cotton ginning	27	7.9	314	92.1	341
Pig farming	283	8.1	3213	91.9	3496
Aerial agricultural services	49	8.8	506	91.2	555
Beef cattle farming	4368	9.3	42 787	90.7	47 155
Other livestock farming, undefined	3	10.3	26	89.7	29
Forestry and logging, undefined	55	13.0	367	87.0	422
Deer farming	21	15.0	119	85.0	140
Logging	528	15.9	2801	84.1	3329
Fruit growing, nec	2427	16.7	12 078	83.3	14 505
Services to agriculture; hunting and trapping	15	16.9	74	83.1	89
Hunting and trapping	90	17.6	422	82.4	512
Grape growing	2859	18.3	12 775	81.7	15 634
Other crop growing, undefined	9	19.6	37	80.4	46
Agriculture, undefined	1478	20.4	5777	79.6	7255
Line fishing	19	20.4	74	79.6	93
Forestry	848	20.6	3271	79.4	4119
Apple and pear growing	607	21.7	2193	78.3	2800
Stone fruit growing	346	22.5	1194	77.5	1540
Livestock farming, nec	505	23.6	1631	76.4	2136
Horticulture and fruit growing, undefined	1196	24.7	3643	75.3	4839
Finfish trawling	71	24.9	214	75.1	285
Squid jigging	3	25.0	9	75.0	12
Aquaculture	1140	27.1	3070	72.9	4210
Services to agriculture, undefined	139	27.4	369	72.6	508
Rock lobster fishing	402	27.5	1062	72.5	1464
Marine fishing, nec	293	28.5	736	71.5	1029
Marine fishing, undefined	174	30.1	404	69.9	578
Services to agriculture, nec	3991	30.3	9172	69.7	13 163
Prawn fishing	322	30.9	721	69.1	1043
Commercial fishing, undefined	982	31.2	2161	68.8	3143
Horse farming	905	32.3	1898	67.7	2803

(Continued next page)

Table C.2 (continued)

ANZSIC class	Metropolitan No. employed	Metropolitan %	Non-Metropolitan No. employed	Non-Metropolitan %	Total No. employed
Kiwi fruit growing	19	32.8	39	67.2	58
Vegetable growing	5147	32.9	10476	67.1	15 623
Agriculture, forestry and fishing, undefined	836	37.5	1392	62.5	2228
Crop and plant growing, nec	1650	38.5	2638	61.5	4288
Services to forestry	1329	42.2	1821	57.8	3150
Poultry farming (eggs)	1482	45.2	1795	54.8	3277
Cut flower and flower seed growing	1872	56.7	1427	43.3	3299
Poultry farming, undefined	1300	59.2	895	40.8	2195
Plant nurseries	7030	62.0	4306	38.0	11 336
Poultry farming (meat)	810	64.2	452	35.8	1262
Agriculture total	**53 630**	**16.2**	**277 100**	**83.8**	**330730**

[a] Metropolitan regions are the 8 capital cities plus the Townsville-Thuringowa, Gold Coast-Tweed, Sunshine Coast, Newcastle, Wollongong and Geelong Statistical Subdivisions. Estimates of metropolitan shares for total agricultural employment are 6 percentage points lower than the BTRE estimates presented in chapter 5 as the BTRE database is based on a lower level of regional classification (Statistical Local Areas). This allows the inclusion in the metropolitan category of some additional regions on the fringes of the capitals and other metropolitan areas. [b] These data are not directly comparable with the ABS Labour Force Survey (LFS) data presented in chapter 5 due to differences in scope, coverage, timing, measurement of underlying concepts and collection methodology. LFS employment estimates are 11-14 per cent higher than census employment estimates for the economy overall and around 30 per cent higher for agriculture. Census under-enumeration and residents temporarily overseas are the main contributors to the difference. Although LFS data provide a better estimate of total employment, they cannot provide reliable estimates of regional industry employment due to sampling methodology (BTRE 2004). Moreover, detailed employment data for the 50 4-digit ANZSIC agricultural industry classes is not available for the LFS.

Source: Unpublished ABS data (2001 Census of Population and Housing data).

Table C.3 Employment in food, beverage and tobacco manufacturing[a], 2003-04

'000 persons, 3 digit ANZSIC

	NSW	*VIC*	*QLD*	*WA*	*SA*	*TAS*	*NT*	*ACT*	*AUST*
Meat and meat products	12.7	9.7	15.1	4.5	3.0	1.0	…	…	**45.9**
Other foods	*5.7	8.2	7.0	*2.3	2.8	1.3	…	*0.1	**27.3**
Bakery products	10.7	5.9	*2.8	*1.6	2.6	*0.4	*0.3	*0.4	**24.8**
Beverage and malt products	*5.2	5.4	*2.2	*1.8	8.7	*0.7	…	*0.1	**24.1**
Dairy products	*3.4	8.1	*2.1	*1.9	*0.7	*0.3	…	…	**16.5**
Food, beverages & tobacco nec	*4.9	5.1	*0.9	*0.3	*0.6	…	…	…	**11.8**
Fruit & vegetable processing	*2.9	*3.6	*2.0	*0.3	*1.4	1.3	…	…	**11.5**
Flour mill and cereal foods	*2.7	*2.9	*0.7	*0.4	*0.1	…	…	…	**6.8**
Tobacco products	*1.1	*0.5	…	…	…	…	…	…	***1.5**
Oil and fat processing	*0.1	*0.4	*0.3	*0.1	…	…	…	…	***0.8**

… Indicates industries where employment is either nil or negligible. [a] See table C.1 for other relevant notes.

Source: ABS (Cat no. 6203.0).

Table C.4 **Food, beverage and tobacco manufacturing employment in metropolitan and non-metropolitan regions[a], 2001**

ANZSIC class	Metropolitan		Non-Metropolitan		Total
	No. employed	*%*	*No. employed*	*%*	*No. employed*
Sugar manufacturing	641	10.4	5536	89.6	6177
Dairy product manufacturing, nec	1391	24.9	4197	75.1	5588
Meat processing	5342	30.0	12 444	70.0	17 786
Meat and meat product manufacturing, undefined	141	31.1	313	68.9	454
Prepared animal and bird feed manufacturing	1946	35.4	3553	64.6	5499
Wine manufacturing	5277	36.4	9204	63.6	14 481
Seafood processing	928	42.1	1274	57.9	2202
Fruit and vegetable processing	4265	43.6	5511	56.4	9776
Milk and cream processing	2750	51.0	2642	49.0	5392
Flour mill product manufacturing	507	52.8	454	47.2	961
Flour mill and cereal food manufacturing nec	663	55.9	523	44.1	1186
Dairy product manufacturing, undefined	1016	56.9	769	43.1	1785
Spirit manufacturing	86	58.5	61	41.5	147
Bacon, ham and smallgoods manufacturing	3424	68.2	1597	31.8	5021
Cereal food and baking mix manufacturing	2951	72.2	1138	27.8	4089
Ice cream manufacturing	1605	73.6	577	26.4	2182
Bread manufacturing	9552	74.4	3281	25.6	12 833
Food manufacturing, nec	6467	74.5	2214	25.5	8681
Oil and fat manufacturing	1217	78.7	329	21.3	1546
Confectionery manufacturing	5773	79.5	1490	20.5	7263
Poultry processing	7093	80.5	1713	19.5	8806
Fbt manufacturing, undefined	10 916	82.6	2295	17.4	13 211
Cake and pastry manufacturing	5198	83.5	1030	16.5	6228
Bakery product manufacturing, undefined	209	85.3	36	14.7	245
Beverage and malt manufacturing, undefined	207	86.6	32	13.4	239
Soft drink, cordial and syrup manufacturing	4168	88.1	565	11.9	4733
Beer and malt manufacturing	3509	89.6	406	10.4	3915
Other food manufacturing, undefined	39	90.7	4	9.3	43
Tobacco product manufacturing	1776	91.3	169	8.7	1945
Biscuit manufacturing	4562	94.1	288	5.9	4850
Total food, beverage and tobacco manufacturing	**93 619**	**59.5**	**63 645**	**40.5**	**157 264**

[a] See table C.2 for source and other relevant notes.

Table C.5 **Selected agriculture-related manufacturing employment in metropolitan and non-metropolitan regions[a], 2001**

	Metropolitan		*Non-Metropolitan*		*Total*
ANZSIC class	*No. employed*	*%*	*No. employed*	*%*	*No. employed*
Log sawmilling	793	16.7	3943	83.3	4736
Wool textile manufacturing	152	22.3	531	77.7	683
Wood chipping	138	23.0	462	77.0	600
Timber resawing and dressing	736	27.4	1948	72.6	2684
Log sawmilling and timber dressing	1379	30.0	3220	70.0	4599
Agricultural machinery manufacturing	1792	35.1	3318	64.9	5110
Fabricated wood manufacturing	943	44.7	1166	55.3	2109
Cotton textile manufacturing	553	46.9	626	53.1	1179
Plywood and veneer manufacturing	530	49.2	547	50.8	1077
Wood and paper product manufacturing	428	50.2	425	49.8	853
Wool scouring	512	55.4	412	44.6	924
Other wood product manufacturing	880	55.6	704	44.4	1584
Leather tanning and fur dressing	1184	62.5	711	37.5	1895
Textile fibre, yarn and woven fabric	274	68.2	128	31.8	402
Pulp, paper and paperboard manufacturing	3299	69.1	1472	30.9	4771
Fertiliser manufacturing	2048	70.5	856	29.5	2904
Pesticide manufacturing	1105	79.3	288	20.7	1393
Food processing machinery manufacturing	1165	87.1	173	12.9	1338
Total selected agriculture-related manufacturing	**17 911**	**46.1**	**20 930**	**53.9**	**38 841**

[a] See table C.2 for source and other relevant notes.

Table C.6 **Selected agricultural-related services employment in metropolitan and non-metropolitan regions[a], 2001**

	Metropolitan		*Non-metropolitan*		*Total*
ANZSIC class	*No. employed*	*%*	*No. employed*	*%*	*No. employed*
Grain storage	334	26.7	916	73.3	1250
Farm produce wholesaling, undefined	124	37.3	208	62.7	332
Farm and construction machinery wholesaling	6001	41.7	8376	58.3	14 377
Meat wholesaling	6573	43.4	8577	56.6	15 150
Farm produce and supplies wholesaling, nec	9709	47.2	10 843	52.8	20 552
Cereal grain wholesaling	901	47.3	1005	52.7	1906
Wool wholesaling	1172	58.8	822	41.2	1994
Dairy produce wholesaling	2939	60.4	1926	39.6	4865
Fruit and vegetable wholesaling	9864	61.1	6275	38.9	16 139
Fish wholesaling	3565	64.3	1983	35.7	5548
Veterinary services	8292	64.9	4485	35.1	12 777
Timber wholesaling	5618	67.1	2757	32.9	8375
Poultry and smallgoods wholesaling	3610	75.9	1146	24.1	4756
Food, drink and tobacco wholesaling, undefined	716	79.4	186	20.6	902
Total selected agriculture-related services	**59 418**	**54.6**	**49 505**	**45.4**	**108 923**

[a] See table C.2 for source and other relevant notes.

Table C.7 **Change in agricultural employment, by industry, 1984-85 to 2003-04**

Sector/industry	*Number employed 2003-04*	*Change from 1984-85 to 2001-02*	*Change from 2001-02 to 2003-04*
	'000 persons	%	%
Agriculture, forestry and fishing	375	6.7	-15.7
Agriculture	320	6.2	-17.1
Horticulture and fruit growing	95	24.8	-2.5
Grain, sheep and beef cattle	166	-3.0	-23.0
Dairy cattle	20	34.7	-36.2
Poultry	10	11.9	4.3
Other livestock	10	-42.2	-18.7
Other crops	11	47.2	-37.3
Services to agriculture	25	68.1	-1.9
Forestry and logging	12	-8.1	-8.0
Commercial fishing	16	53.8	-14.9

Source: ABS (Cat no. 6291.0.55.001).

Table C.8 **Changing composition of the agriculture workforce, 1984-85, 1994-95 and 2003-04**

	Agriculture		Mining		Manufacturing		Services		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	%	%	%	%	%	%	%	%	%	%
Full-time										
1984-85	69	12	90	7	72	20	53	26	58	24
1994-95	62	15	88	9	70	20	47	26	51	25
2003-04	60	15	86	10	69	19	43	25	47	24
Part-time										
1984-85	5	14	1	2	2	5	4	16	4	14
1994-95	7	16	1	2	3	7	7	20	6	18
2003-04	9	16	2	2	4	8	9	23	8	20
Total										
1984-85	74	26	91	9	74	25	57	42	62	38
1994-95	69	31	89	11	73	27	54	46	57	43
2003-04	69	31	88	12	73	27	52	48	56	44

Source: ABS (Cat no. 6291.0.55.001).

Table C.9 **Part-time employment trends by sector/industry, 1984-85 to 2003-04**

Sector/industry	*Number employed 2003-04*	*Share of industry employment 2003-04*	*Change from 1984-85 to 2001-02*	*Trend average annual growth 1984-85 to 2001-02*	*Change from 2001-02 to 2003-04*
	'000 persons	%	%	%	%
Agriculture, forestry and fishing	94	25.0	45.6	1.4	-14.2
Agriculture	84	26.2	40.6	1.1	-15.0
Horticulture and fruit growing	26	27.1	58.5	2.2	5.9
Grain, sheep and beef cattle	42	25.7	27.7	0.4	-22.3
Dairy cattle	6	30.4	93.3	3.6	-28.4
Poultry	2	24.2	28.6	0.6	-21.7
Other livestock	3	26.4	-5.2	-2.2	-23.7
Other crops	2	20.6	107.5	3.9	-46.4
Services to agriculture	5	18.4	148.8	5.2	-3.5
Forestry and logging	1	11.1	65.0	3.3	-18.2
Commercial fishing	3	20.9	86.3	2.1	-12.1
Mining	4	4.0	33.1	1.3	9.2
Manufacturing	129	12.0	45.2	2.1	8.9
Services	2495	31.2	129.4	4.7	6.7
Total	2721	28.6	117.9	4.4	5.9

Source: ABS (Cat no. 6291.0.55.001).

Table C.10 **Composition of employment by worker age**

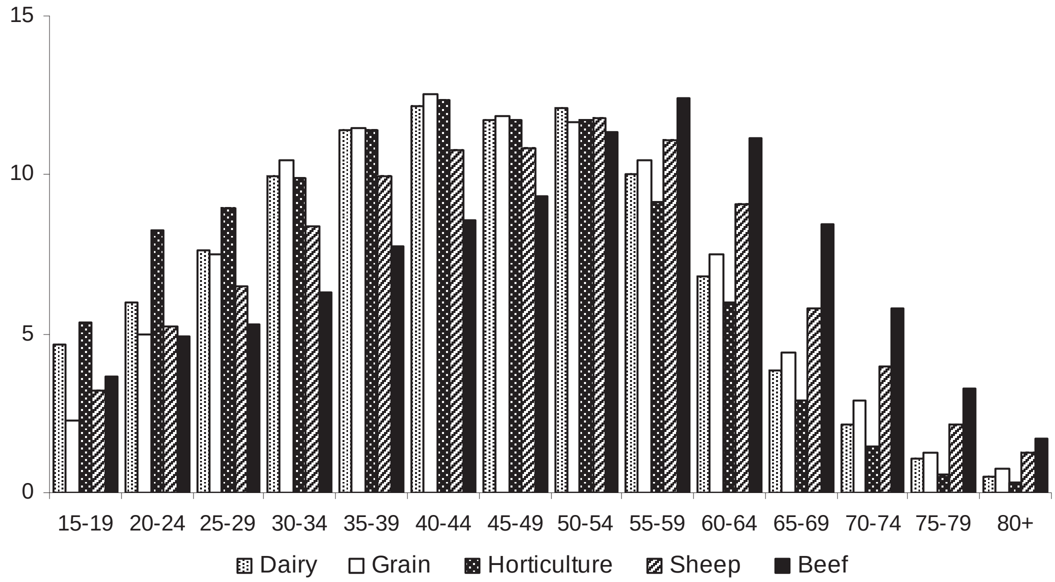
Per cent

	1984-85	*1994-95*	*2003-04*
15-24			
Agriculture	15.6	11.7	11.5
All industries	23.7	19.9	18.0
25-34			
Agriculture	20.5	19.7	17.3
All industries	26.9	25.5	23.0
35-44			
Agriculture	24.5	22.3	20.9
All industries	24.1	25.7	24.1
45-54			
Agriculture	19.1	20.4	21.3
All industries	15.8	19.8	22.2
55 and over			
Agriculture	20.4	25.9	29.0
All industries	9.6	9.1	12.7

Source: ABS (Cat no. 6291.0.55.001).

Figure C.1 **Farmer age distribution by industry, 2001**

Per cent of industry employment



Data source: Unpublished ABS data (2001 Census of Population and Housing).

Table C.11 **Share of employment by occupations, 2003-04**

Per cent

Occupation	*Agriculture*	*Mining*	*Manufacturing*	*Services*	*Total*
Managers and administrators	53	8	10	6	8
Professionals	3	18	10	21	19
Associate professionals	3	10	6	14	12
Trades and related workers	5	21	26	11	13
Clerks, sales and service workers	6	8	13	34	30
Production and transport workers	7	30	17	7	9
Labourers and related workers	24	5	18	7	9

Source: ABS (Cat no. 6291.0.55.001).

D Determining productivity peaks

The substantial volatility evident in agricultural multifactor productivity (MFP) data (discussed in chapter 6) makes it difficult to identify underlying trends in productivity. In order to make a meaningful comparison of productivity over time, it is necessary to make comparisons which lessen the ‘noise’ created by this volatility.

For the market sector as a whole, the ABS recommends comparing average growth rates between productivity peaks in order to undertake useful comparative analyses.[1] Peak years are defined as peak deviations of the MFP index from its long run trend. The trend series is constructed using an 11 term Henderson moving average (see ABS 2003 for a discussion of the Henderson trend calculations). Deviations (D) are determined as the percentage difference between the original MFP index (MFPA) and the trend series (MFPT); that is:

$$D_t = (MFPA_t / MFPT_t \text{ -1}) \times 100 \qquad \{1\}$$

The peak years are determined by the local maxima of this series.

The ABS has estimated peak years for market sector MFP using this approach.[2] However, estimating productivity trends for agriculture across market sector peak years does not adequately control for cyclical factors unique to agriculture such as droughts. For example, at the time of the most recent market-sector peak identified by the ABS — 1998-99 — agricultural MFP was only slightly above trend and continued to rise in three subsequent years to reach 6 per cent above trend in 2001-02. However, 2001-02 was not a peak year for the ABS market sector series. For this reason, as noted in PC (2003, p. 209), ‘peak-to-peak periods are probably best constructed on a sector by sector basis’.

To achieve this for the agriculture sector, a Hodrick-Prescott smoothing filter was used to generate a D series {1} from the original MFP estimates. The productivity peaks for agriculture were then determined using a decision rule that identified local maxima.

1 Although others, such as Quiggin (2001) have argued for a different basis for determining starting and ending dates for trend analysis.

2 *Australian System of National Accounts*, Cat. no. 5204.0, November 2002.

Following PC 2003, the rule used here to identify the peaks was:

$$\mathbf{PEAK_t = IF\ (D_t > \lambda)\ and\ (D_{t+1} < D_t)\ and\ (D_{t-1} < D_t) = 1} \qquad \{2\}$$

where λ is the key threshold value. In PC (2003), λ was set at 1 since the standard deviation of D_t was just above unity for manufacturing. However, choosing a value of 1 for λ is not appropriate for agriculture. The standard deviation of D_t for agriculture (8.3) was much higher than the value recorded for manufacturing, and indeed any other sector (box D.1).

In the first instance the value of λ was set at 9 for agriculture. Using this 'at least one standard deviation' decision rule, between 1974-75 and 2003-04, there were only two productivity peaks — 1978-79 and 1983-84. Following PC (2003), smaller MFP peaks were identified to allow further analysis using a smaller value for λ. When the decision rule was relaxed to at least one-third of a standard deviation above the MFP series (that is, $\lambda = 3$), three additional, smaller, agricultural MFP peaks were identified — 1990-91 and the pre-drought years 1993-94 and 2001-02.

The analysis in chapter 6 is largely based on the three peaks of 1983-84, 1993-94 and 2001-02. These peaks were chosen because they allow ready comparison of the agricultural sector's relative MFP performance over the past two decades.

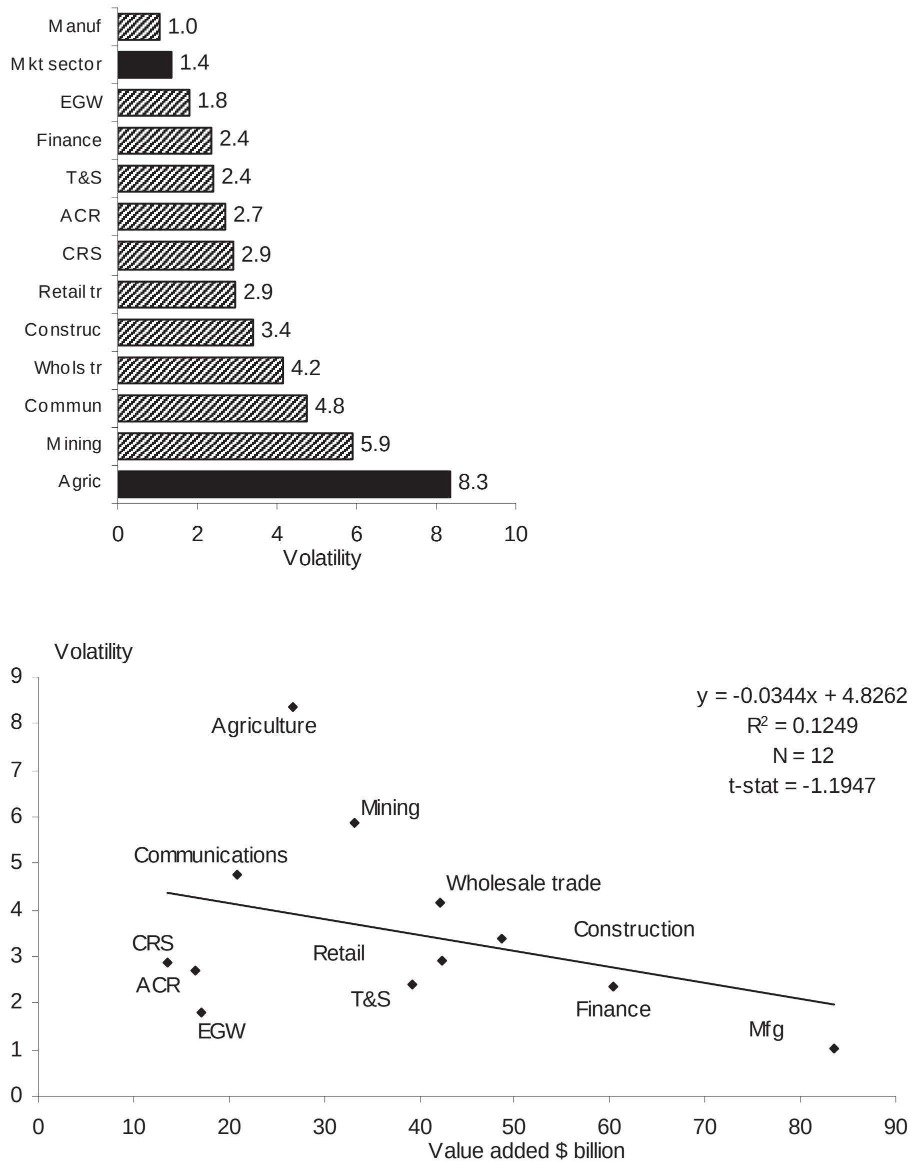
Box D.1 **MFP volatility and sector size**

It could be expected that a sector’s size plays some role in its volatility. This is due to aggregation effects which occur when the peaks and troughs for the various industries comprising each sector occur at different times and partially cancel each other out. For example, market sector volatility was lower than all sectors with the exception of manufacturing. Nevertheless, a comparison of the volatility in sectoral MFP suggests that sector size is not the main driver of sectoral volatility. While the largest sector, manufacturing, recorded the lowest volatility, there were a number of small sectors that also recorded low volatility (for example, electricity, gas and water; accommodation, cafes and restaurants and community and recreational services, figure D.1).

A regression of sectoral volatility against sectoral size (value added in 2003-04, constant 2001-02 prices) found only a weak negative correlation which was not statistically significant at the 5 or 10 per cent level. Hence, it appears likely that characteristics unique to each sector are the major drivers of sectoral MFP volatility.

Figure D.1 **Sectoral MFP volatility[ab] and sector size, 1974-75 to 2003-04**

Sector volatility *Volatility and sector size*



a Sector volatility is defined as the standard deviation of D_t — as in {1} above. **b** CRS, ACR, EGW, T&S refer to Cultural and recreational services, Accommodation, cafes and restaurants, Electricity, gas and water, and Transport and storage, respectively.

Data source: ABS Cat. no. 5204.0.

References

ABARE (Australian Bureau of Resource Economics) 2005a, *Australian Crop Report*, June.

—— 2005b, *Australian Commodities: forecasts and issues*, vol. 12 no. 1, March quarter.

—— 2004a, ‘Australian sheep industry productivity’, *Australian lamb*, November.

—— 2004b, *Australian Commodity Statistics 2004*, Canberra.

—— 2004c, ‘Production systems, productivity and profit’, *Australian dairy*, September.

—— 2004d, ‘Production and sale of beef cattle’, *Australian beef*, December.

—— 2004e, *Australian beef industry*, *productivity*, November.

Abdalla, A., Tran, Q.T., Berry, P. and Foster, M. 2003, ‘Agricultural biotechnology, potential for use in developing countries’, *Australian commodities*, vol. 10, March quarter, pp. 111-119.

ABS 2004, *Use of information technology on farms*, ABS Cat. no. 8150.0.

—— 2003, *A guide to interpreting — monitoring trends*, ABS Cat. no. 1349.0.

—— 2002a, ‘A hundred years of agriculture data’, *ABS Year Book Australia*.

—— 2002b, ‘ANZSIC and TREC — Two views on trade’, *International Merchandise Trade Australia 2002*.

—— 2002c, ‘Understanding agricultural exports data’, *ABS Year Book Australia*.

—— 2002d, ‘Data confidentiality’ in international merchandise trade Australia 2002, *ABS Year Book Australia*.

—— 2001, *Census of population and housing*, Australian Bureau of Statistics.

—— 1993, *Australian and New Zealand Standard Industrial Classification (ANZSIC)*, ABS Cat. no. 1292.0.

Agriculture and Agri-Food Canada 2003, *An Overview of the Canadian agriculture and agri-food system*, Canada, http://www.agr.gc.ca/cb/apf/pdf/bg_con_overvu_e.pdf (accessed April 2005).

Alexander, F. and Kokic, P. 2005, *Productivity in the Australian grains industry*, ABARE *e*Report 05.3, prepared for the Grains Research and Development Corporation, Canberra, February.

Andrews, N., Buetre, B., Davidson, A. and McDonald, D. 2003, *Agricultural trade reform: benefits for Australian broadacre agriculture*, ABARE Conference Paper 03.7 presented at Queensland Regional Outlook Conference, Toowoomba, 21 May.

Barber, M. and Cutbush, G. 2005, 'Contract farming: the future of agriculture?', *Farm Policy Journal*, vol. 2, no. 1, February, pp. 4-14.

Barr, N. 2004, *The Micro-dynamics of change in Australian agriculture 1976-2001*, Australian Census Analytic Program, Australian Bureau of Statistics, Canberra.

——, 2003, *Future agricultural landscapes*, paper presented to Leading with Diversity: The National Planning Conference, Adelaide, 31 March – 2 April.

——, 2002, 'Social Trajectories for rural landscaping', *Agribusiness connections – farm, food and resource issues*, Agribusiness Association of Australia, Autumn, http://www.agrifood.info/10pub_conn_Aut2002_5.htm (accessed 8 February 2005).

Bradley, R., and Gans, J. 1998, 'Growth in Australian cities', *The Economic Record*, vol. 74, no. 226, pp. 266–278.

BTRE (Bureau of Transport and Regional Economics) 2004, *Focus on regions no.*

Butlin, N.G. 1962, *Australian domestic product, investment and foreign borrowing 1861-1938/39*, Cambridge University Press, Cambridge.

Cary, J., Barr, N., Aslin, H., Webb, T. and Kelson, S. 2001, *Human and social aspects to capacity to change to sustainable management practices*, Bureau of Resources Sciences, Canberra.

Clark, C., Geer, T. and Underhill, B. 1996, *The changing of Australian manufacturing*, Staff Information Paper, Industry Commission, AGPS, Canberra.

Coelli, T.J. and Prasada Rao, D.S. 2003, *Total factor productivity growth in agriculture: a malmquist index analysis of 93 Countries*, 1980 to 2000, Working Paper no. 02/2003, Centre for Efficiency and Productivity Analysis, School of Economics, The University of Queensland.

Corish, P. 2004, *A 21st Century vision for modern Australian agriculture*, Telstra Address by National Farmers Federation President, 4 August.

Cullen, R.B. and Cullen, M.J. 1994, *An Analysis of qualification profiles in Australian industry: agriculture forestry and fishing*, Occasional Paper 95/1 Australian National Training Authority, Brisbane.

Dairy Australia 2004, *Australian dairy industry in Focus 2004*, Dairy Australia, Melbourne.

Dee, P. and Hanslow, K. 2000, *Multilateral liberalisation of services trade*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

DAFF (Department of Agriculture, Fisheries and Forestry) 2005, *Australian agriculture and food sector stocktake*, Department of Agriculture, Fisheries and Forestry, Canberra.

DFAT (Department of Foreign Affairs and Trade) 2005, *Statistical analysis and retrieval system (STARS) database*, *market information and analysis section*, Barton.

—— 2004b, *Exports of primary and manufactured products Australia 2003-04*, Canberra.

Dixon, P. and Menon, J. 1995, *Measures of intra-industry trade as indicators of factor market disruption*, Centre of Policy Studies General Paper no. G-113, April.

Economic Research Service United States Department of Agriculture 2001, *agricultural policy reform in the WTO — the road ahead*, Burfisher, M.E. (ed), Agricultural Economics Report no. (AER802), May.

Econtech 2005, *Australia's farm-dependent economy: analysis of the role of Agriculture in the Australian economy*, Farm Institute, Surry Hills, Australia.

Edwards, G. 2003, 'The story of deregulation in the dairy industry', *The Australian Journal of Agricultural and Resource Economics*, vol. 47, no. 1, pp. 75–98.

Ferguson, J. and Simpson, R. 1995, 'The Australian rural labour market' *National Focus*, A National Farmers' Federation Research Paper vol. 9, National Farmers' Federation, November, Canberra.

Freeman, F., Melanie, J., Roberts, I., Vanzetti, D., Tielu, A. and Beutre, B. 2000, *The impact of agricultural trade liberalisation on developing countries*, ABARE Research Report 2000, Canberra.

Garnaut, J., and Lim-Applegate, H. 1998, *People in farming*, ABARE Research Report 98.6, ABARE, Canberra.

—— and Rasheed, C. 1998, 'Computers: use in management and electronic commerce in Australian farming', *Australian Farm Surveys Report*, ABARE.

——, ——, and Rodriguez, G. 1999, *Farmers at work: the gender division*, ABARE Research Report 99.1, ABARE, Canberra.

Gooday, J. 1995, *Women on farms: A survey of women on Australian broadacre and dairy family farms, 1993-94*, ABARE Research Report 95.10, ABARE, Canberra.

Gordon, W. 2005, *Australian wine grape production projections to 2006-07*, ABARE *e*Report 05.2, prepared for the Grape and Wine Research and Development Corporation, Canberra, January.

Grubel, H.G. and Lloyd, P.J. 1975, *Intra-industry trade: the theory and measurement of international trade in differentiated products*, McMillan Press, London.

Ha, A. and Chapman, L. 2000, 'Productivity growth trends across Australian broadacre industries', *Australian Commodities*, vol.7, no. 2, June quarter.

Hallam, D. 2003, 'The organic market in OECD countries: past growth, current status and future potential', *Organic Agriculture: Sustainability, Markets and Policies*, OECD, pp. 179–186.

Harris, S. 1990, 'Agricultural trade and agricultural trade policy', in Williams D.B. (ed) *Agriculture in the Australian Economy*, 3rd edn., Sydney University Press, pp. 342-360.

Higgins, T.J. and Constable, G. 2004, 'Development, regulation and use of genetically modified crops in Australia', *Farm Policy Journal*, vol. 1, no. 2, August quarter, pp. 14-23.

Hogan, J., Shaw, I. and Berry, P. 2004, *A review of the Australian dairy industry*, ABARE *e*Report 04.24, prepared for the Primary Industries Standing Committee Working Group on Dairy, August, Canberra.

Hooper, S., Berry, P. and Martin, P. 2004, *Grains industry, performance and outlook*, ABARE and Grains Research and Development Corporation, March.

——, Blias, A. and Ashton, D. 2003, *Australian prime lamb industry 2003*, Report of the Australian Agricultural and Grazing Industries Survey of Prime Lame Producers, ABARE Research Report 03.2, Canberra.

——, Martin, P., Love, G. and Fisher, B. 2002, Farm size and productivity: where are the trends taking us?', *Australian Commodities*, vol. 9, no. 3, September quarter, pp. 495-500.

IC (Industry Commission) 1998, *Microeconomic reforms in Australia: a compendium from the 1970s to 1997*, Research Paper, AGPS, Canberra, January.

—— 1997, *Assessing Australia's productivity performance*, AGPS, Canberra, September.

—— 1995, *Research and development report*, no. 44, AGPS, Canberra.

Johnson, D.G. 2000, ‘Population, food and knowledge’, *American Economic Review*, vol. 90, no. 1, pp. 1–14.

Keogh, M (ed), 2005, *Farm Policy Journal*, vol. 2, no 1, February quarter, pp. 1-2.

—— 2004, ‘Off the sheep’s back and on to the tractor — the changing face of farming in Australia’, *Farm Policy Journal*, vol. 1, no. 1, May quarter, pp. 4-16

Knopke, P., Strapazzon, L. and Mullen, J. 1995, ‘Productivity growth: total factor productivity growth on Australian broadacre farms’, *Australian Commodities*, vol. 2, no. 4, December quarter, pp. 486-497.

Lester, I.H. 1994, *Australia’s food and nutrition*, Australian Institute of Health and Welfare, AGPS, Canberra.

Lipton, K., Edmonson, W. and Manchester, A. 1998, *The food and fibre system: contributing to the US and world economies*, USDA Agriculture Information Bulletin No. 742, July.

Lu, L. and Headley, D. 2004, ‘The Impact of the 2002-03 Drought on the economy and agricultural employment’, *Economic Roundup*, Autumn, pp. 25–43.

Maddock, R. and McLean, I. 1987, *The Australian economy in the long run*, Cambridge University Press, Melbourne.

Martin, P., King, J., Puangsumalee, P., Tulloh, C. and Treadwell, R. 2005, *Australian farm survey results*, March, ABARE, Canberra.

——, Lubulwa, M., Riley, C. and Helali, S. 2000, ‘Farm performance: managing risks’, *Outlook 2000*, Proceedings of the National Agriculture and Resources Outlook Conference, Canberra, 29 February – 2 March, vol. 2, *Agriculture and Regional Australia*, ABARE, pp. 41–62.

Martin, W. and Mitra, D. 2001, ‘Productivity Growth in agriculture and manufacturing’, *Economic Development and Cultural Change*, vol. 49, no. 2, pp. 403–23.

McGovern, M. 1999, ‘On the unimportance of exports to Australian agriculture’, *Australasian Journal of Regional Studies*, vol. 5, no. 2, pp. 229–252.

McLachlan, R., Clark, C. and Monday, I. 2002, *Australia’s service sector: a study in diversity*, Productivity Commission Staff Research Paper, AGPS, AusInfo, Canberra.

Murtough, G. and Waite, M. 2000, *The growth of non-traditional employment: are jobs becoming more precarious?*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

NCC (National Competition Council) 2004, *Dairy – Now and then: the Australian dairy industry since deregulation*, NCC Occasional Series, AusInfo, Canberra.

—— 2000, *Securing the future of Australian agriculture: barley*, NCC Community Information, Canberra.

OECD (Organization for Economic Co-operation and Development) 2004a, *OECD Agricultural outlook 2004–2013*, OECD, Paris.

—— 2004b, *OECD Agricultural policies 2004: at a glance*, OECD, Paris.

—— 2003a, *Evolution of Agricultural support in real terms in OECD countries from 1986 to 2002*, Working Party on Agricultural Policies and Markets, OECD, Paris.

—— 2003b, *Farm household income: issues and policy responses*, OECD, Paris.

—— 1998, *Agricultural policy reform and the rural economy in OECD Countries*, OECD, Paris.

—— 1995, *Technological change and structural adjustment in OECD Agriculture*, OECD, Paris.

PC (Productivity Commission) 2004a, *Australian pigmeat industry*, Draft Report, Melbourne.

—— 2004b, *Impacts of native vegetation and biodiversity regulations*, Report no. 29, Melbourne.

—— 2004c, *Trade and Assistance Review 2003-04*, Annual Report Series 2003-04, Productivity Commission, Canberra, December.

—— 2003, *Trends in Australian manufacturing*, Commission Research Paper, AusInfo, Canberra.

—— 2002, *Citrus growing and processing*, Report no. 20, AusInfo, Canberra.

—— 1998, *Battery eggs sale and production in the ACT*, Research Report, AusInfo, Canberra.

Peterson, D., Dwyer, G., Appels, D. and Fry, J. 2004, *Modelling water trade in the southern Murray-Darling Basin*, Productivity Commission Staff Working Paper, Melbourne, November.

Quiggin, J. 2001, 'The Australian productivity "miracle": a sceptical view', *Agenda*, vol. 8, no. 4, pp: 801-817.

Raney, T. 2004, 'Agricultural biotechnology for developing countries: an FAO PERSPECTIVE', *Farm Policy Journal*, vol. 1, no. 2, August quarter, pp. 4–13.

Rasheed, C., Rodriguez, G. and Garnaut, J. 1998, 'Patterns of Employment of men and women in farming', in ABARE, *Australian Farm Surveys Report 1998*, ABARE, Canberra, pp. 43–47.

RBA (Reserve Bank of Australia) 1996, Australian economic statistics, dX Database, Econdata (vendor), released: 20 November 1996.

RIRDC (Rural Industries Research and Development Corporation) 2004, *Annual Report 2003-2004*, RIRDC, Canberra.

—— 2003, *Research priorities 2004-2005*, RIRDC, Canberra.

Roberts, I., Davidson, A., Podbury, T. and Tulpule, V. 2004, 'Uncertainty in trade negotiations — what does it mean for Australian agriculture?', in *Australian Commodities*, vol. 11, no. 1, March quarter, pp. 143–154.

——, Podbury, T., Freeman, F., Tielu, A., Vanzetti, D., Andrews, N., Melanie, J., and Hinchy, M. 1999, *Reforming world agricultural trade policies*, ABARE Research Report 99.12, Canberra.

Rowthorn, R. and Ramaswamy, R. 1997, *Deindustrialization — its causes and implications*, Economic Issues Paper no. 10, IMF, Washington DC.

Rural Industry Working Group 2001, *Skill needs now and in the future in the rural industry*, Prepared for the Honourable Dr David Kemp MP, Minister for Education, Training and Youth Affairs.

Salce, M. 1995, 'Beware the farmer — she's out to change agriculture' in *Outlook 95*, proceedings of the National Agricultural and Resources Outlook Conference, Canberra, 7–9 February, vol. 2, *Agriculture*, ABARE, Canberra, pp. 329–336.

Synapse Consulting Pty Ltd 1998, *Farmer education and training: issues for Research and Development*, RIRDC Publication 98/26, RIRDC, Canberra.

Taylor, J.E. (2001) 'Human capital: migration and rural population change' in Stamoulis, K. G. (ed), *Food, Agriculture and Rural Development: Current and Emerging Issues for Economic Analysis and Policy Research*, FAO.

Tonts, M. and Black, A. 2002, *The impact of changing farm business structures on rural communities*, RIRDC Report 02/027, RIRDC, Canberra.

Treasury (Department of the Treasury) 2005, *Budget strategy and outlook 2005-06, Budget Paper No.*

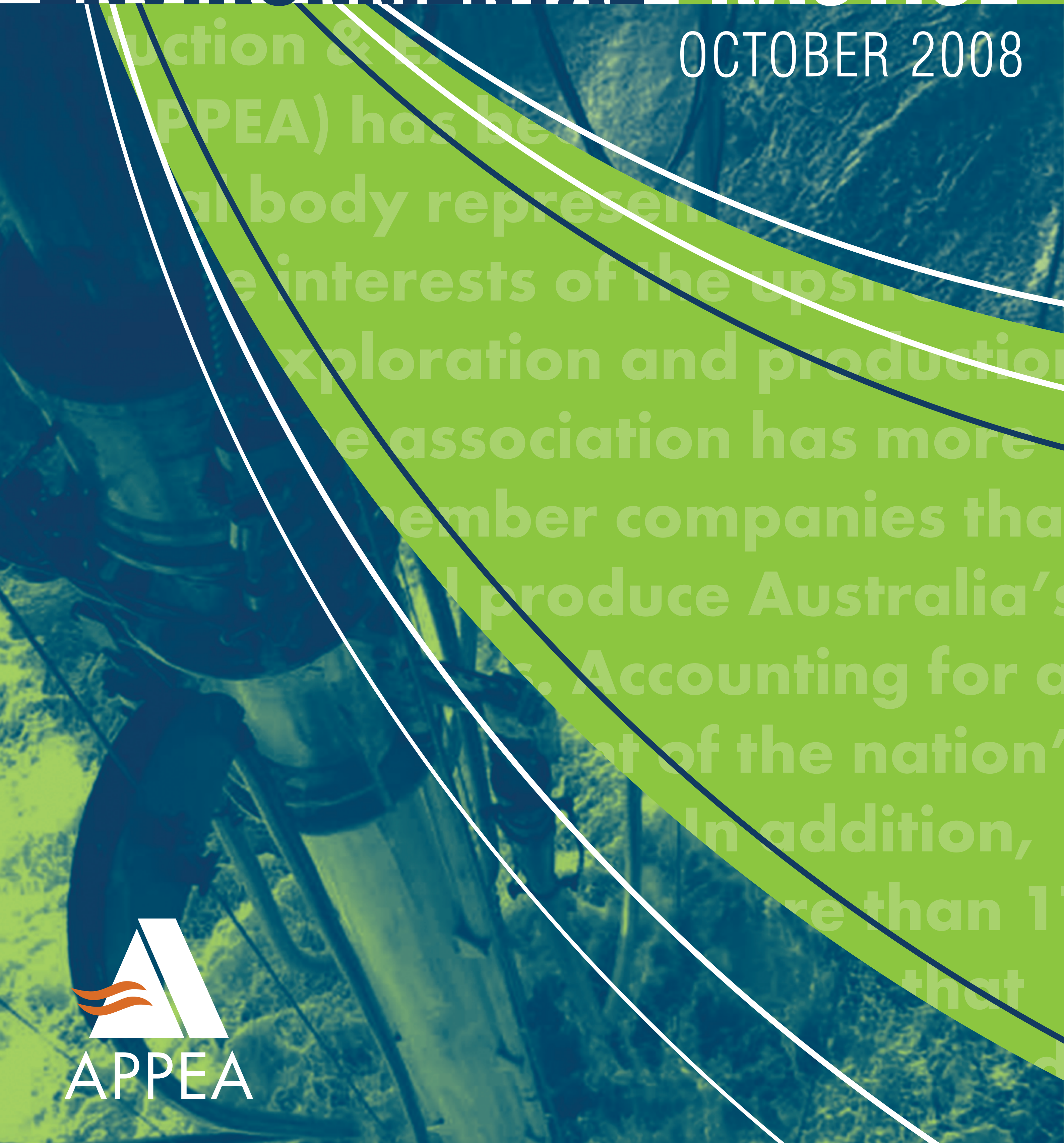
West, G. 2002, 'Decomposition of exports and GDP into direct and indirect industry contributions', *Australasian Journal of Regional Studies*, vol. 8, no. 2, pp. 143–164.

Wonder, B. and Fisher, B. 1990, 'Agriculture in the economy', in Williams D.B. (ed) *Agriculture in the Australian Economy*, 3rd edn., Sydney University Press, pp. 50–67.

Wynen, E. 2003, *Organic agriculture in Australia — levies and expenditure*, RIRDC Report 03/002, RIRDC, Canberra.

code of ENVIRONMENTAL PRACTICE

OCTOBER 2008



APPEA

THE AUSTRALIAN PETROLEUM PRODUCTION AND EXPLORATION ASSOCIATION

Prepared for:

Australian Petroleum Production and Exploration Association
Level 10, 60 Marcus Clarke Street
Canberra ACT 2600

T (02) 6247 0960
F (02) 6247 0548
E appea@appea.com.au

Prepared by:

RPS Ecos Pty Ltd
ABN 57 081 918 194
Level 2, 47 Colin Street
West Perth WA 6005

T (08) 9382 4744
F (08) 9382 1177
E admin04@rpsgroup.com.au
www.rpsgroup.com.au

Disclaimer

The APPEA Code of Environmental Practice provides an outline of environmental objectives which represent guidance on key aspects of good environmental practice in the petroleum industry.

However, APPEA does not accept any responsibility or liability for any person's use of, or reliance on, this Code of Environmental Practice, or for any consequences of such use or reliance.

The Code of Environmental Practice has been developed with input provided by members of APPEA. The Code of Environmental Practice has not been reviewed or approved by Government bodies or regulators, and does not have legal force or effect. Therefore, compliance with the Code of Environmental Practice will not necessarily mean compliance with legal obligations. Each person accessing the Code of Environmental Practice must acquaint themselves with its own legal obligations, and must, on a case-by-case basis, form its own judgement as to the conduct required in order to satisfy those legal obligations. The conduct required will depend on the individual circumstances. It can not be assumed that compliance with the Code of Environmental Practice will in any way be sufficient.

Legal obligations and standards change over time as does knowledge on the environment. While APPEA intends to review and update the Code of Environmental Practice from time to time, APPEA's capacity to do so is limited. Accordingly, APPEA does not represent that the Code of Environmental Practice is up-to-date.

CONTENTS

PREAMBLE

In Australia, exploration and production operations are conducted within a wide range of environments. These operations require effective management in order to be sustainable.

The Australian Petroleum Production and Exploration Association (APPEA) and its member companies are committed to sound resource and environmental management practices as an integral part of industry operations.

Recognising the need to avoid or minimise and manage impacts to the environment, this code of environmental practice includes four basic recommendations to APPEA members undertaking activities:

- Assess the risks to, and impacts on, the environment as an integral part of the planning process
- Reduce the impact of operations on the environment, public health and safety to as low as reasonably practicable and to an acceptable level by using the best available technology and management practices
- Consult with stakeholders regarding industry activities
- Develop and maintain a corporate culture of environmental awareness and commitment that supports the necessary management practices and technology, and their continuous improvement.

The standard of performance achieved by reducing impacts to 'as low as reasonably practical and to an acceptable level' is a dynamic measure that will continue to evolve in line with improved risk identification and assessment methods, technological advances, changed circumstances, performance monitoring, government requirements, community expectations and other relevant information. As such, by reducing impacts to as low as reasonably practical, APPEA members will in effect be striving for continuous improvement.

Member companies, however, must determine the specific needs of their own operations, including relevant regulatory requirements, and develop a suitable management culture, environmental management systems and the technology necessary to avoid, mitigate and manage potential environmental impacts.

Consultation and communication with stakeholders is an important part of this process. Stakeholder engagement as part of the planning process is the start of an ongoing consultation program.

Companies should be capable of demonstrating their commitment to protecting the environment and to maintaining public health and safety during all phases of operation. Companies achieve these outcomes on behalf of their shareholders, employees, and on behalf of present and future generations of Australians.

Aim of the Code of Environmental Practice

The United Nations Agenda 21 (United Nations 1992) outlined the role of business and industry in sustainable development and stated that environmental responsibility for business means:

> "[the] responsible and ethical management of products and processes from the point of view of health, safety and environmental aspects [impacts]. Towards this end, business and industry should increase self-regulation, guided by appropriate codes, charters and initiatives integrated into all elements of business planning and decision-making and fostering openness and dialogue with employees and the public." (30.26)

Against this background, APPEA supports the development and application of an industry-wide code of environmental practice and indeed first published its own code in 1977.

This edition of the Code of Environmental Practice reflects the trend away from prescriptive legislation to objective-based legislation. Developing objectives enables stakeholders to make explicit the outcomes desired, while providing operators flexibility in choosing the appropriate procedures to meet those objectives. Furthermore, this approach provides the opportunity for adequate planning and communication with stakeholders.

This Code of Environmental Practice gives guidance on objectives to be achieved when managing environmental impacts associated with petroleum exploration and production. APPEA recognises that these objectives must be reviewed against the actual operations being carried out, the specific environment in which the operations are being conducted, changes in stakeholder perceptions and expectations, advances in technology and legal requirements.

However, APPEA believes that this Code of Environmental Practice will form an effective and time-saving starting point for the development of specific objectives for a given project, program, operation or environment. Objectives developed with the guidance of this Code of Environmental Practice, based on a formal risk assessment process and in consultation with stakeholders, would reflect good industry practice.

This Code of Environmental Practice is one of an integrated series of documents that provide an industry framework adding support to member companies' management systems. As outlined in the following section, other key documents that comprise APPEA's integrated series include:

- APPEA Principles of Conduct
- APPEA Environmental Policy
- MCMPR Principles for Engagement with Communities and Stakeholders
- Company Environmental Management Plans.

These documents are central to achieving three of APPEA's key objectives:

- Self-regulation
- Industry operation to the highest standards
- Continued access to areas for exploration and production.

PRINCIPLES, POLICY AND INDUSTRY FRAMEWORK

Overview

This section outlines the existing APPEA principles and policies that provide support for this Code of Environmental Practice. The relationship between the Code of Environmental Practice and other documents produced by industry to fulfil or support statutory obligations is also explained. The relationship between these documents is graphically represented in Figure 1.

APPEA Principles of Conduct

The APPEA Principles of Conduct (APPEA 2003) provide the basis for achieving APPEA's mission of a legislative, administrative, economic and social framework which efficiently and effectively facilitates safe, environmentally responsible, socially responsible and profitable oil and gas exploration, development and production.

The APPEA Principles of Conduct (APPEA 2003) are based on the following nine principles:

- Ethical and responsible business practices;
- Sustainable development considerations integrated into company decision making;
- Foster economic growth and business development, generate government revenue, provide commercial returns to the industry and contribute to the wealth generated by Australia's natural resource base;
- Health, safety, environmental and community risk management strategies that are based on sound science and effective communication;
- Continuously seek opportunities to improve health, safety and environmental performance in addressing risks posed by our operations to employees, contractors, the public and the environment;
- Contribute to the conservation of biodiversity and protection of the environment through responsible management of our operations and their impacts;
- Foster economic and social development of the communities in which we operate;
- Respect the rights and dignity of our workforce, and deal fairly with our workforce, suppliers and the communities in which we operate; and
- Open and effective engagement with the communities in which we operate.

These Principles set the tone and provide guidance for this Code of Environmental Practice.

MCMPR Principles for Engagement with Communities and Stakeholders

The Ministerial Council on Minerals and Petroleum Resources (MCMPR) released the document entitled *Principles for Engagement with Communities and Stakeholders* in 2005. APPEA provided input into the development of these principles, which set out the framework for effective liaison between the resources sector, the community and stakeholders. It has five broad principles based on:

- Communication;
- Transparency;
- Collaboration;
- Inclusiveness; and
- Integrity.

The document sets the context for activities conducted by APPEA member companies and has been used as input to this Code of Environmental Practice.

APPEA Environmental Policy

The Australian Petroleum Production & Exploration Association (APPEA) will promote this environment policy amongst its members and encourage, and where appropriate, support member companies to:

- Comply, at a minimum, with applicable laws, regulations, standards and guidelines for the protection of the environment and in their absence, adopt the best practicable means to prevent or minimise adverse environmental impacts.
- Work and consult with appropriate government agencies drafting policies laws, regulations or procedures to protect the environment.
- Ensure that adequate waste management practices are carried out based on the prevention, minimisation, recycling, treatment and disposal of wastes.
- Provide adequate training to enable employees and contractors to adopt environmentally responsible work practices and to be aware of their stewardship responsibilities.
- Promote research to conserve resources, minimise wastes, improve understanding of risks and impacts and to cost effectively minimise these, to improve environmental protection.
- Develop emergency plans and procedures so that incidents can be responded to in a timely and effective manner.
- Develop and maintain management systems to identify, control and monitor risks and compliance with government regulations and industry guidelines.
- Monitor environmental effects and assess environmental performance at all stages of exploration, development, production and rehabilitation.
- Communicate openly with government, non-government bodies and the public in a timely manner on environmental issues which relate to the industry's operations.

In promoting such an environmental policy among its members, APPEA will:

- Lead the industry in achieving with government, sound environmental legislation.
- Provide a range of forums to address environmental issues.
- Collate and disseminate information on environmental performance and best practice among member companies.
- Recognise excellent environmental performance.

Company environmental management plans

Environmental Management Plans (or Environment Plans) are required under various State and Commonwealth Petroleum Acts. Prior to undertaking activities, companies must submit these plans to the regulatory bodies for approval. These plans typically include the objectives, standards and criteria that govern activities and detail the procedures that may be followed during the course of any activity to ensure achievement of the objectives.

Underpinning company environment management plans is a formal risk assessment process based on sufficient specific information to ensure effective risk assessment.

Environmental Management Plans for all activities should clearly identify the environmental objectives and then outline procedures and practices to assist operations personnel in ensuring the achievement of these objectives. It is advisable that procedures remain flexible and allow personnel to exercise initiative to adapt to the situation-at-hand.

The APPEA Code of Environmental Practice provides guidance for the development of such plans. In particular, it is the intent of this Code to provide direction on environmental objectives, with the aim of promoting consistently high standards for petroleum operations across the industry.

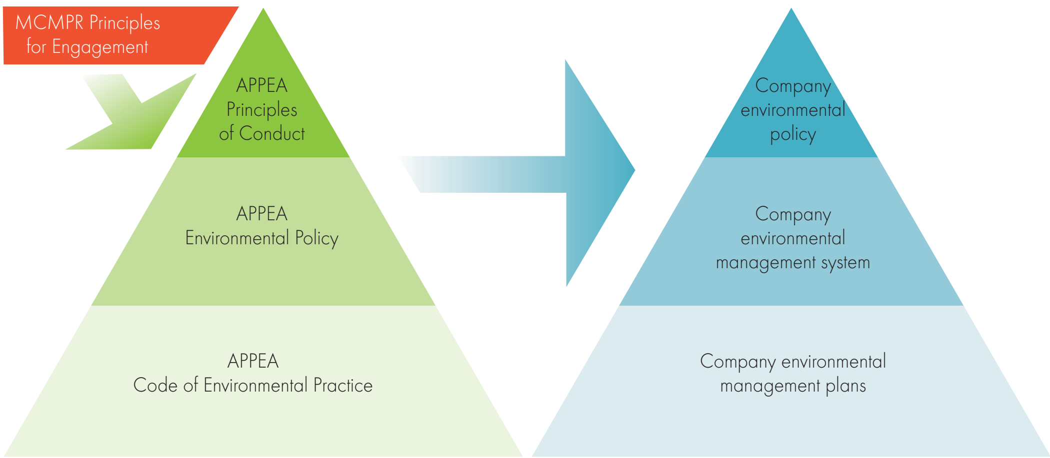


Figure 1: Relationship between documents

OVERVIEW OF LEGISLATIVE FRAMEWORK IN AUSTRALIA

Australia is a federation of states known in a formal sense as the Commonwealth of Australia. Hence, the Federal Government also is referred to as the Commonwealth Government. Each Australian state has a government and a third tier of local government also exists.

Petroleum activities will require consideration of both Commonwealth and State laws and local by-laws, although the extent of involvement of each tier of Government will vary depending on location and activity.

From an environmental point of view, petroleum activities always involve at least two major departments at both Commonwealth and State level: the resource department and the environment department. Invariably, permission to proceed with an activity will require approval from both these departments in the State and/or Commonwealth jurisdictions.

The States have primary sovereignty regarding resource matters onshore within State borders and in coastal waters out to a distance of 3 nautical miles from a base line (low water mark, but across some bays and around some islands).

Offshore petroleum laws are, in a practical sense, common across all jurisdictions (except for royalty or its equivalent provisions) for Commonwealth and State waters. In Commonwealth waters, the authority to regulate activities and coordinate assessment and approvals is delegated to State resource agencies under the Commonwealth petroleum legislation. State resource agencies fulfil these responsibilities in consultation with Commonwealth and other State agencies.

Commonwealth environment legislation applies to both Commonwealth and State waters and lands. As such, in areas of State lands and coastal waters, both State and Commonwealth legislation may apply. At a State level, environment legislation differs between the jurisdictions, although the processes and outcomes are, in a practical sense, very similar.

APPEA maintains a list of applicable legislation (www.appea.com.au) as an aide memoir for companies carrying out petroleum activities. It is, however, of paramount importance that companies ensure that they have carried out a thorough process of identifying all legislation (Acts, regulations, policies, guidelines etc) that will affect the specific activities they wish to carry out and the specific areas within which they wish to operate.

Environmental legislation requires the following general steps:

- An assessment of the impact the activities will have on the environment of the area (i.e. develop the information and assess the risk);
- In most cases, the development of acceptable objectives that must be achieved in managing the environmental impact; and
- A demonstration that the company has the financial, technical and management competencies to ensure the outcomes will be achieved.

ENVIRONMENTAL OBJECTIVES — GENERAL

Overview

Environmental legislation applicable to petroleum activities requires environmental objectives to be developed that reflect the environmental outcome following successful management of activities and (where appropriate) remediation of impacts.

The following environmental objectives reflect those previously developed by companies in consultation with stakeholders for specific projects in specific areas. The objectives in this Code of Environmental Practice are intended to provide an efficient starting point for member companies when developing their site- or activity-specific environmental management objectives, plans, guidelines and procedures.

Environmental issues included in the following sections are based on industry understanding. Risk assessment may be used for specific projects, but has not been used here to link potential hazards with environmental issues because of the breadth of the subject matter.

The potential environmental impacts from the upstream oil and gas industry are well documented elsewhere and have been summarised in this Code of Environmental Practice below (see also Swan JM, Neff JM and Young PC (Eds) 1994; E&P Forum and UNEP 1997; IADC 2006). However, there is always potential for a specific combination of site and activity to raise other potential impacts.

The remainder of this Section (Section 4) addresses environmental impacts that are common to all activities.

Planning and design

Activity

Planning and design (in a general sense) is intrinsic to all stages of exploration and production activities. The degree to which planning will be needed will depend on the scale and nature of the proposed activity and its location. However, the importance of planning cannot be underestimated in achieving acceptable environmental performance and effective stakeholder engagement. Planning is central to the initial application for an exploration permit and then through the various exploration, production and decommissioning stages.

Design (again in a broad use of the term) is equally important, as many potential environmental issues can be best mitigated at the design stage of activities. Appropriate design also is important to stakeholder acceptance of a project or activity.

Environmental issues

- It is necessary to identify all environmental issues that are required to be addressed for the activities to proceed.
- This should be followed by the development of measures to obtain any information that is lacking and of measures to mitigate the environmental impacts.
- There should be proper demonstrable accountability for all decisions taken.

Objectives	Example potential performance criteria
Activities are planned to avoid environmental impacts, or, where this is not possible, to minimise impacts to as low as reasonably practical and to a level that is acceptable.	■ Be able to demonstrate that the planning and design processes were fit-for-purpose and included: ● a structured assessment of the risks to the environment ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all stakeholders and potential issues ● initial engagement with stakeholders and regulatory bodies early in planning phase ● structured consultation with stakeholders throughout the planning and design phases ● a structured process to identify all legislative requirements. ■ Accountability was documented for all decisions taken with the potential to cause significant impact to the environment.
Activities are planned to avoid areas that are environmentally or culturally significant, or, where this is not possible, to minimise the impact to as low as reasonably practical and to a level that is acceptable.	■ Be able to demonstrate that environmentally or culturally significant areas were avoided by documenting a robust site selection criteria and process, including: ● a structured assessment of the significance of areas ● consideration of viable alternatives and their associated environmental impacts ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the choice of areas to be avoided ● a structured process to identify all stakeholders and potential issues ● structured consultation with stakeholders throughout the planning and design phase. ■ The processes and procedures adopted to ensure that objectives are met were documented. ■ Accountability was documented for all decisions taken about areas to be avoided.

Assessment of environmental risks

Activity

The formal assessment of events that can cause harm to the environment is applicable to all operations undertaken by an organisation.

Environmental issues

It is necessary to identify risks (likelihood and consequence) to the environment and the appropriate mitigation measures so that the risks can be reduced to as low as reasonably practical, are in accordance with legislation and are acceptable.

The risk assessment process should be adapted for each activity, project or operation to ensure that it is fit-for-purpose. All risk assessments, no matter how simple or informal, should be documented.

Objectives	Example potential performance criteria
Activities are assessed to ensure that risks to the environment are avoided or are as low as reasonably practical, aligned with any legislative requirements and are acceptable.	■ Be able to demonstrate by a documented formal risk assessment process that the environmental risks were assessed and company management accepted the resultant level of managed risks ■ Fit-for-purpose approach to risk assessment of smaller projects.

Emergency response plan

Activity

All activities require appropriate emergency response plans to be prepared, in place and practised.

Environmental issues

Potential environmental impacts may result from unplanned incidents such as leaks, spills, explosions, incursions into protected areas or bushfires. Emergency response, clean-up and rehabilitation measures are needed to minimise potential environmental impacts.

Objectives	Example potential performance criteria
To ensure that in the event of an emergency appropriately trained personnel and other resources are available to respond to and meet the objectives of the emergency response plan.	■ Be able to demonstrate that: ● emergency response plans were prepared and practised ● practice or actual responses to emergencies met pre-determined performance criteria ● resources were adequate to address emergencies.

Training and induction

Activity

Training and induction are essential parts of any project or program. It is essential that all staff have the appropriate environmental knowledge and skills necessary to undertake their work. There will be a range of matters that will need to be communicated, including:

- legislative requirements and company policies
- environmental objectives and work procedures for a particular activity
- competencies needed for a particular task that may impact on the environment.

Environmental issues

Each project or program will have a unique set of environmental issues that need to be communicated to, and understood by, the personnel involved. Personnel need to be competent to carry out all work required to the necessary standard.

Objectives	Example potential performance criteria
Personnel are able to meet environmental management objectives.	■ There were no incidents attributable to inadequate training. ■ Be able to demonstrate that: ● appropriate and defined environmental training and induction was available for all relevant activities ● records of environmental training were completed.

Auditing

Activity

An environmental audit program is necessary to demonstrate that management systems exist, are being implemented and are achieving the objectives. Audits can be undertaken either in-house or by external personnel, depending on the purpose of the audit.

Environmental issues

Environmental impacts may occur if the systems and procedures in place are not sufficiently robust. Regular auditing is necessary to ensure that proper systems and procedures are in place and are working effectively.

Objectives	Example potential performance criteria
To ensure that management systems and monitoring requirements are appropriate to the activity or operation, are being implemented and are achieving the environmental objectives.	■ There were no incidents that have failure of audit to detect non-conformance as a contributing cause. ■ Be able to demonstrate that: • management systems and audits were of an appropriate scope and were carried out at appropriate intervals • all environmental matters identified as non-conforming or requiring improvement were closed out.

Consultation and communication

Activity

Third parties can be directly or indirectly impacted by petroleum activities. Regulators need to interact as the activities develop. An effective consultation and communication process which both informs and educates the stakeholders and the proponent is essential if significant issues are to be addressed in a timely manner.

The degree of consultation will depend on the nature and scale of any planned activity and the nature of the communities in which they occur. Clear consultation and communication regarding a planned activity may further reduce impacts, improve research focus and produce better environmental outcomes.

Environmental issues

Third parties can be impacted directly or indirectly by any planned activity. Potential impacts may include:

- disturbance of natural environment
- disruption of marine and land resource activities
- disturbance to sites of cultural heritage significance
- reduction of aesthetic value of an area
- noise, air, light or other forms of pollution
- increased traffic on local roads
- social impacts through economic development.

Third parties may have knowledge that is significant to the project.

Objectives	Example potential performance criteria
To ensure that third parties have been consulted about the activities so that informed decisions can be taken to avoid or, where avoidance is not possible, reduce to as low as practicable and to an acceptable level the impacts on third party interests.	■ Be able to demonstrate that communication with third parties was in accordance with *Principles for Engagement with Communities and Stakeholders* (MCMPR 2005). ■ Responses to issues raised by third parties were documented with appropriate accountability for decisions. ■ Physical and management actions can be demonstrated that avoid the risks to third party issues or reduce them to as low as reasonably practical and to an acceptable level.

ENVIRONMENTAL OBJECTIVES — OFFSHORE

Geophysical surveys

Activity

Aerial surveys may be used in addition to marine-based seismic acquisition surveys. This involves either gravimetric or magnetic methods.

A typical seismic acquisition survey involves a vessel towing one or more strings of hydrophones (streamers), each up to several kilometres long. A noise source is typically emitted by an air gun array that is usually close to the vessel. The pulse of acoustic energy travels as a wave into the earth and is reflected off any geological structures. This is then recorded by the hydrophones.

Support vessels may also be present during the seismic acquisition survey. Crews may be mobilised from a port or via a helicopter.

Environmental issues

Program-specific risks should be identified during the planning phase. Generally, potential environmental issues associated with geophysical surveys may include:

- disturbance to other marine resource users
- ship-strike
- accidental loss of streamers
- accidental fuel, oil or chemical spill
- localised reduction in water quality by wastes, leaks (fuel, streamer fill)
- physiological effects, physical harm or disruption to behaviour of marine life due to acoustic impacts
- pollution from vessel air emissions
- disturbance to cultural heritage sites (e.g. shipwrecks)
- introduction of marine pests
- disturbance to benthos via anchors, grounding or collision.

Objectives	Example potential performance criteria
To reduce disturbance to fishing operations or other marine users to as low as reasonably practical and to an acceptable level.	■ There were no complaints from the commercial fishing operators or other marine users. ■ Be able to demonstrate adherence to agreed procedures.
To reduce the risk of collision with other vessels in accordance with maritime standards and to an acceptable level.	■ There were no incidents with other marine resource users. ■ Proper marine safety procedures were in place and observed.
To reduce the risk of release of substances into the marine environment to as low as reasonably practical and to an acceptable level.	■ There was no accidental loss of substances to sea during mobilisation, seismic operations or demobilisation. ■ Be able demonstrate that: • appropriate management procedures were in place and were implemented • grey water, sewage and other wastes were disposed of in accordance with statutory requirements and agreed procedures.

Objectives	Example potential performance criteria
To reduce the volume of wastes produced to as low as reasonably practical and to an acceptable level. Ensure that any wastes produced are disposed of in appropriate onshore facilities.	■ Be able demonstrate that: ● appropriate management procedures were in place and implemented ● all solid wastes, chemicals and other wastes were disposed of or recycled at appropriate facilities in accordance with legislative requirements and agreed procedures ● technological innovation was considered and adopted as appropriate as part of a continuous improvement process.
To reduce the impact on cetaceans and other marine life to as low as reasonably practical and to an acceptable level.	■ There were no breaches of legislative requirements; and ■ Be able to demonstrate that: ● appropriate management measures were implemented in accordance with legislative requirements, guidelines and agreed procedures ● the need for further studies to close any knowledge gaps was considered and appropriate research was undertaken ● any new knowledge was incorporated into the planning and design of the activity.
To reduce the impacts from events such as spills and loss of equipment to an acceptable level and reduce the risk to as low as reasonably practical.	■ There were no reportable accidental losses of hydrocarbons to sea during development or production operations. ■ Be able demonstrate that: ● appropriate management procedures were in place and are implemented ● an appropriate emergency response plan was in place.
To reduce the risk of introduction of marine pests to as low as reasonably practical and to acceptable levels.	■ There were no introductions of invasive or alien marine species recorded. ■ Be able to demonstrate that appropriate quarantine management measures were implemented in accordance with legislative requirements and agreed procedures.
To reduce the impacts to benthic communities to acceptable levels and to as low as reasonably practical.	■ Be able to demonstrate: ● that areas of sensitivity related to benthic communities were adequately addressed in the planning process ● compliance with legislative quarantine requirements, guidelines and agreed procedures ● the need for further studies to close any knowledge gaps was considered and appropriate research was undertaken ● any new knowledge was incorporated into the planning and design of the activity.
To reduce greenhouse emissions to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that the planning and design processes included: ● a structured assessment of the reduction of greenhouse emissions ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all legislative requirements. ■ Accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

Drilling operations

Activity

Exploration drilling is used to explore and evaluate geological structures. Once a hydrocarbon bearing reservoir is discovered, development drilling is likely to follow to allow production and/or increase hydrocarbon reserves.

Exploration wells offshore are usually drilled vertically using a mobile offshore drilling unit (MODU). Offshore reservoirs are usually developed with fixed platforms or subsea developments.

The drilling of a well will involve installing surface casing and cementing this in place, installing and testing blow-out preventers (BOPs), followed by drilling and subsequent intermediate casing being installed and cemented into place.

Drilling fluids are usually water-based, but in certain circumstances an oil-based or synthetic fluid system could be used. Drilling fluids are generally recycled during drilling activities and may be discharged overboard at the conclusion of drilling.

Cuttings discharged usually range from very fine to very coarse (< 1 cm) particle sizes. Support vessels will also be on location in association with the MODU.

Environmental issues

Program-specific risks should be identified during the planning phase. Generally, potential environmental issues associated with drilling operations may include:

- disruption to the activities of other marine users
- disturbance to cultural heritage values
- disturbance to marine species
- introduction of marine pests
- smothering of, or disturbance to, benthic flora and fauna
- reduction in quality of the ambient air and noise conditions
- light emissions from the MODU or support vessels
- pollution due to the discharge of wastes including drill cuttings, drilling fluids, wash water, sewage, Normally Occurring Radioactive Material (NORM) and other wastes
- hydrocarbon spills
- loss of drill fluid and/or blow-out
- damage to well integrity
- cross-flow between fluid strata
- accident involving the MODU
- accidents involving support services.

Objectives	Example potential performance criteria
To reduce the disturbance to fishing operations or other marine users to as low as reasonably practical and to an acceptable level.	■ There were no complaints from the commercial fishing operators or other marine users. ■ Appropriate consultation was conducted and liaison was maintained during the operation. ■ Be able to demonstrate that: ● appropriate management measures were in place and were implemented ● appropriate management systems were in place to record complaints ● appropriate systems were in place to document consultation and communication with stakeholders.
To avoid disturbance of areas of cultural heritage significance where practicable and reduce the risk of impacts to cultural heritage value to as low as reasonably practical and to an acceptable level.	■ There was no unauthorised disturbance to areas of cultural heritage significance. ■ Be able to demonstrate that: ● appropriate consultation was conducted ● an approved cultural heritage management plan was in place ● management measures were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures.
To reduce the risk of introduction of marine pests to as low as reasonably practical and to an acceptable level.	■ There were no introductions of invasive or alien marine species recorded. ■ Be able to demonstrate that: ● appropriate quarantine management measures were implemented in accordance with legislative requirements and agreed procedures ● an appropriate monitoring program was in place to identify quarantine breaches.
To reduce the impacts to benthic communities to acceptable levels and to as low as reasonably practical.	■ Be able to demonstrate that: ● areas of sensitivity related to benthic communities were adequately addressed in the planning process ● appropriate measures were in place to reduce offshore footprint (including that associated with the disposal of drill cuttings) ● procedures were in place to monitor and record discharged cuttings and drilling fluid volumes and characteristics.
To reduce the impact of air emissions, noise emissions and light to an acceptable level and to as low as reasonably practical.	■ There were no complaints by other marine users. ■ Be able to demonstrate that: ● appropriate management measures were in place to minimise impacts, and these were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures ● appropriate management systems were in place to record complaints ● appropriate systems were in place to document consultation and communication with stakeholders.
To reduce the volume of wastes produced to as low as reasonably practical and to an acceptable level. Ensure that relevant wastes are disposed of in appropriate onshore facilities.	■ Be able demonstrate that: ● appropriate management measures were in place and implemented ● all solid wastes, chemicals and other wastes were disposed of or recycled at appropriate facilities in accordance with legislative requirements and agreed procedures.

Objectives	Example potential performance criteria
To reduce the risk of release of material into the marine environment to as low as reasonably practical and to an acceptable level.	■ There was no accidental loss of hydrocarbons to sea during mobilisation, drilling operations or demobilisation. ■ Be able demonstrate that: ● appropriate management procedures were in place and are implemented ● grey water, sewage and other wastes were disposed of in accordance with statutory requirements and agreed procedures.
To reduce the risk of damage to well integrity and cross-flow between fluid strata to as low as reasonably practical and to acceptable levels.	■ There was no evidence of unacceptable damage to well integrity or cross-flow. ■ Be able to demonstrate that: ● appropriate drilling procedures were in place and implemented ● an appropriate monitoring program was in place and implemented and appropriate records kept.
To reduce the risk of collision with other vessels in accordance with maritime standards.	■ There were no incidents with other marine resource users. ■ Be able to demonstrate that appropriate management measures were implemented in accordance with legislative requirements, guidelines and agreed procedures.
To reduce greenhouse emissions to as low as reasonably practical and to acceptable levels.	■ Be able to demonstrate that the planning and design processes included: ● a structured assessment of the reduction of greenhouse emissions ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all legislative requirements. ■ Accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

Development and production

Activity

The actual configuration of offshore production facilities will be site-specific depending on the nature of the hydrocarbon produced, the size of the reservoir and local environmental conditions. Once the hydrocarbon reaches the surface, it can be processed through a central production facility which gathers and processes the produced fluids (gas, oil and water).

If the field is large enough, there could be satellite platforms linked by subsea flow lines to a central facility. In shallower water, there could be a number of smaller wellhead platforms linked to a central processing facility. These can be via a fixed platform that is either manned or unmanned.

The product could be exported via a ship or pipeline to shore.

Environmental issues

Project-specific risks should be identified during the planning phase. Environmental issues for development and production are usually assessed within an environmental approvals framework applicable to the jurisdiction within which it falls. Generally, potential environmental issues associated with development and production operations may include:

- disruption to the activities of other marine users
- disturbance to cultural heritage values
- disturbance to benthic and pelagic species, and other wildlife (such as birds)
- physical disturbance to the seafloor

- introduction of marine pests
- acoustic disturbances (vibrations, drilling equipment for production wells)
- reduction in air quality associated with emissions
- reduction in visual amenity
- light pollution
- pollution due the discharge of wastes including produced water, solid wastes, NORM, chemicals fuel, hydrocarbons, abandoned equipment and other wastes
- contamination associated with solid and chemical waste disposal onshore
- formation water disposal
- hydrocarbon spills
- cross-flow between fluid strata
- increased risk of ship-strike to marine fauna
- risks to the environment and public safety from the facilities
- socio-economic impacts.

Objectives	Example potential performance criteria
To reduce the impact on other marine resource users to as low as reasonably practical and to an acceptable level.	■ There were no complaints by other marine users. ■ Appropriate consultation was conducted and effective liaison was maintained. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate management systems were in place to record complaints • appropriate systems were in place to document consultation and communication with stakeholders.
To reduce the impact on the beneficial uses of marine waters, including ecosystem maintenance to as low as reasonably practical and to an acceptable level.	■ Impacts were in accordance with legislative requirements and approved (predicted) levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate biological and water quality surveys were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures.
To reduce the impacts to benthic communities to acceptable levels and to as low as reasonably practical.	■ Be able to demonstrate that: • areas of sensitivity related to benthic communities were adequately addressed in the planning process • appropriate measures were in place to reduce offshore footprint.
To avoid disturbance of areas of cultural heritage significance where practicable and reduce the risk of impacts to cultural heritage value to as low as reasonably practical and to an acceptable level.	■ There was no unauthorised disturbance to areas of cultural heritage significance. ■ Be able to demonstrate that: • appropriate consultation was undertaken • an approved cultural heritage management plan was in place • management measures were implemented • appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures.

Objectives	Example potential performance criteria
To reduce the risk of introduction of marine pests to as low as reasonably practical and to acceptable levels.	■ There were no introductions of invasive or alien marine species recorded. ■ Be able to demonstrate that: • appropriate quarantine management measures were implemented in accordance with legislative requirements and agreed procedures • an appropriate monitoring program was in place to identify quarantine breaches.
To reduce risks to the abundance, diversity, geographical spread and productivity of marine species to as low as reasonably practical and to acceptable levels.	■ Impacts were in accordance with predicted levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate biological surveys were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures.
To reduce the impact of planned air emissions, noise emissions and light to as low as reasonably practical and to an acceptable level.	■ There were no complaints by other marine users. ■ Be able to demonstrate that: • appropriate management measures were in place to minimise impacts, and these were implemented • appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures • appropriate management systems were in place to record complaints • appropriate systems were in place to document consultation and communication with stakeholders.
To reduce impact of routine waste discharges on the marine environment to as low as reasonably practical and to an acceptable level.	■ Discharges of materials such as sewage and putrescibles waste were in accordance with legislative requirements and an approved waste management plan. ■ Impacts were in accordance with legislative requirements and approved (predicted) levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate monitoring programs were conducted to enable discharges to be recorded, impacts to be identified, and the results communicated in accordance with agreed procedures.
To reduce the risk of any unplanned release of material into the marine environment to as low as reasonably practical and to an acceptable level.	■ There were no reportable accidental losses of substances to sea during development or production operations. ■ Be able demonstrate that: • appropriate management procedures were in place and were implemented • an appropriate emergency response plan was in place.
To reduce the impact of produced formation water on the marine environment to as low as reasonably practical and to an acceptable level.	■ Discharge volume and quality was in accordance with legislative requirements and approved levels. ■ Impacts were in accordance with legislative requirements and approved (predicted) levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate monitoring programs were conducted to enable discharges to be recorded, impacts to be identified, and the results communicated in accordance with agreed procedures.

Objectives	Example potential performance criteria
To reduce the risk of cross-flow between fluid strata to as low as reasonably practical and to an acceptable level.	■ There was no evidence of cross-flow. ■ Be able to demonstrate that: ● appropriate reservoir management procedures were in place and implemented ● an appropriate monitoring program was in place and implemented and appropriate records kept.
To reduce risks to public safety to as low as reasonably practical and to an acceptable level.	■ There were no accidents or incidents involving the public as a result of production operations. ■ Be able demonstrate that: ● appropriate safety management procedures were in place and were implemented ● an appropriate emergency response plan was in place.
To reduce greenhouse emissions to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that the planning and design processes included: ● a structured assessment of the reduction of greenhouse emissions ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all legislative requirements ● accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

ENVIRONMENTAL OBJECTIVES — ONSHORE

Geophysical surveys

Activity

Aerial surveys based on either gravimetric or magnetic methods may be used in addition to ground based seismic acquisition surveys.

The purpose of surveys is to identify underlying geological features that may contain hydrocarbons. Seismic surveys use an energy source generally from a vibrating pad mounted beneath a vehicle, or from controlled explosive charges. The energy is transmitted as a pulse through surface layers and is reflected off geological structures and recorded by a series of acoustic receivers. Special cables transmit the electrical signals to a mobile laboratory where they are processed and recorded.

Environmental issues

Program-specific risks should be identified during the planning phase. Generally, potential environmental issues associated with onshore geophysical surveys may include:

- disturbance to cultural heritage values
- erosion and changes to surface hydrology
- vegetation clearance
- introduction of weeds, pests or pathogens
- disturbance to wildlife or livestock
- disturbance to local land uses
- acoustic disturbances (vibrations, explosions)
- low level noise and light from camps
- soil, surface water and groundwater contamination associated with effluent disposal, waste disposal and spills of fuel, hydrocarbons or chemicals
- reduction in visual amenity associated with the presence of seismic lines
- unauthorised third party access of seismic lines.

Objectives	Example potential performance criteria
To avoid disturbance of sites of cultural heritage significance where practicable and reduce the risk to cultural heritage value to as low as reasonably practical and to an acceptable level.	■ There was no unauthorised disturbance to sites of cultural heritage significance. ■ Be able to demonstrate that: • an approved cultural heritage management plan was in place • management measures were implemented • appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures.
To reduce impacts on soils and surface drainage (including gibber and sand dunes) to acceptable levels and to reduce the risk of impact to as low as reasonably practical.	■ There were no long-term erosion issues or problems due to surface drainage changes. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate rehabilitation measures were undertaken • appropriate surveys were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures • appropriate monitoring programs were in place to adequately assess the effectiveness of rehabilitation measures.
To reduce impacts to vegetation and wildlife habitats to acceptable levels and to reduce the risk of impact to as low as reasonably practical.	■ There was no unauthorised clearing of vegetation. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented to minimise footprint and manage clearing activities • appropriate rehabilitation measures were undertaken • appropriate biological assessments were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures • appropriate monitoring programs were in place to adequately assess the effectiveness of rehabilitation measures.
To reduce the risk of introduction (or spread) of weeds, pests and pathogens to as low as reasonably practical and to an acceptable level.	■ There were no weeds, pests and pathogens introduced (or spread). ■ Be able to demonstrate that: • appropriate weed and pest management measures were implemented in accordance with legislative requirements and agreed procedures • appropriate monitoring programs were conducted to enable introductions to be identified, and the results communicated in accordance with agreed procedures • any weeds, pests and pathogens detected were appropriately dealt with • where relevant, dieback mitigation procedures were implemented and strictly adhered to.
To reduce the impact on other land users to an acceptable level and to reduce the risk of impact to as low as reasonably practical.	■ There were no complaints by other land users. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate management systems were in place to record complaints • appropriate systems were in place to document consultation and communication with stakeholders.

Objectives	Example potential performance criteria
To reduce the impact of noise, light, odours, traffic and vibration to an acceptable level and to reduce the risk of impacts to as low as reasonably practical.	■ There were no complaints by other land users regarding amenity. ■ Be able to demonstrate that: ● appropriate management measures were in place to minimise impacts, and these were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures ● appropriate management systems were in place to record complaints ● appropriate systems were in place to document consultation and communication with stakeholders.
To reduce the volume of waste produced to as low as reasonably practical and to an acceptable level. Ensure that relevant wastes are disposed of in appropriate facilities.	■ Be able demonstrate that: ● waste was managed in accordance with a waste management plan ● all solid wastes, chemicals and other wastes were disposed of or recycled at appropriate facilities in accordance with legislative requirements and agreed procedures.
To reduce visual impacts of seismic survey operations to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that: ● areas of visual sensitivity were adequately addressed in the planning process ● appropriate measures were in place to reduce visual impact (including weaving of lines).
To discourage third party access following completion of operations to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that third party access is not encouraged or facilitated as a result of seismic surveys.
To reduce greenhouse emissions to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that the planning and design processes included: ● a structured assessment of the reduction of greenhouse emissions ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all legislative requirements. ■ Accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

Drilling operations

Activity

The actual location of well sites, access tracks and associated infrastructure will be site-specific depending on the location and characteristics of the hydrocarbon reservoir and local environmental conditions.

Onshore, individual well sites have a small footprint (usually in the order of 250m^2). Drilling operations require the establishment of a well pad suitable to safely accommodate the drilling rig and associated equipment. Tracks may need to be constructed to facilitate access. Water is required by the drilling process and may be pumped or trucked to site or a new bore drilled.

The workforce is typically accommodated in a mobile camp located in close proximity to the well site.

Environmental issues

Program-specific risks should be identified during the planning phase. Generally, potential environmental issues associated with onshore drilling operations may include:

- disturbance to cultural heritage values
- erosion and changes to surface hydrology
- vegetation clearance
- introduction of weeds, pests or pathogens
- disturbance to wildlife or livestock
- disturbance to local land uses
- low-level noise and light from camps
- acoustic disturbances (vibrations, drilling equipment)
- low-level reduction in local air quality associated with emissions from vehicles, drilling equipment, and well testing
- soil, surface water and groundwater contamination associated with effluent disposal, waste disposal and spills of fuel, hydrocarbons or chemicals
- cross-flow between fluid strata
- reduction in visual amenity
- third party access
- risks to public safety.

Objectives	Example potential performance criteria
To avoid disturbance of sites of cultural heritage significance where practicable and reduce the risk of impacts to cultural heritage value to as low as reasonably practical and to an acceptable level.	■ There was no unauthorised disturbance to sites of cultural heritage significance. ■ Be able to demonstrate that: • there was appropriate cultural heritage consultation • an approved cultural heritage management plan was in place • management measures were implemented • appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures.

Objectives	Example potential performance criteria
To reduce impacts on soils of vegetation disturbance, surface drainage (including gibber) and other activities to acceptable levels and reduce the risk of impacts to as low as reasonably practical.	■ There were no long-term erosion issues or problems due to vegetation disturbance, surface drainage or other activities. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate rehabilitation measures were undertaken • appropriate surveys were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures • appropriate monitoring programs were in place to adequately assess the effectiveness of rehabilitation measures.
To maintain the beneficial uses of surface and groundwater, including ecosystem maintenance and reduce the risk of impacts to as low as reasonably practical and to an acceptable level.	■ Impacts to water quality were in accordance with legislative requirements and agreed levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate monitoring programs were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures.
To reduce impacts to vegetation and wildlife habitats to acceptable levels and reduce the risk of impacts to as low as reasonably practical.	■ There was no unauthorised clearing of vegetation. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented to minimise footprint and manage clearing activities • appropriate rehabilitation measures were undertaken • appropriate biological surveys were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures • appropriate monitoring programs were in place to adequately assess the effectiveness of rehabilitation measures.
To reduce the risk of introduction (or spread) of weeds, pests and pathogens to as low as reasonably practical and to an acceptable level.	■ There were no weeds, pests and pathogens introduced (or spread). ■ Be able to demonstrate that: • appropriate quarantine management measures were implemented in accordance with legislative requirements and agreed procedures • appropriate monitoring programs were conducted to enable introductions to be identified, and the results communicated in accordance with agreed procedures • any weeds, pests and pathogens detected were appropriately dealt with.
To reduce the impact on other land users and livestock to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ There were no complaints by other land users regarding. ■ Be able to demonstrate that: • appropriate management measures were in place to minimise impacts to land users and livestock, and these were implemented • appropriate management systems were in place to record complaints • appropriate systems were in place to document consultation and communication with stakeholders.
To reduce the impact of noise, light, odours, traffic and vibration to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ There were no complaints by other land users regarding amenity. ■ Be able to demonstrate that: • appropriate management measures were in place to minimise impacts, and these were implemented • appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures • appropriate management systems were in place to record complaints • appropriate systems were in place to document consultation and communication with stakeholders.

Objectives	Example potential performance criteria
To reduce planned emissions to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ Impacts were in accordance with legislative requirements and approved (predicted) levels. ■ Be able to demonstrate that: • appropriate management measures were in place and were implemented • appropriate monitoring programs were conducted to enable emissions to be recorded, impacts to be identified, and the results communicated in accordance with agreed procedures.
To reduce the volume of waste produced to as low as reasonably practical and to an acceptable level. Ensure that relevant wastes are disposed of in appropriate facilities.	■ Be able demonstrate that: • waste was managed in accordance with an approved waste management plan • all solid wastes, chemicals and other wastes were disposed of or recycled at appropriate facilities in accordance with legislative requirements and agreed procedures.
To reduce the risk of unplanned release of substances to land to as low as reasonably practical and to an acceptable level.	■ There were no reportable accidental losses of substances to land during drilling operations. ■ Be able demonstrate that: • appropriate management procedures were in place and were implemented • an appropriate emergency response plan was in place.
To reduce the risk of cross-flow between fluid strata to acceptable levels and to as low as reasonably practical.	■ There was no evidence of cross-flow. ■ Be able to demonstrate that: • appropriate reservoir management procedures were in place and implemented • an appropriate monitoring program was in place and implemented and appropriate records kept.
To reduce visual impacts of drilling operations to an acceptable level.	■ Be able to demonstrate that: • areas of visual sensitivity were adequately addressed in the planning process • appropriate measures were in place to reduce visual impact.
To reduce risks to public safety to as low as reasonably practical and to an acceptable level.	■ There were no accidents or incidents involving the public as a result of drilling operations. ■ Be able demonstrate that: • appropriate safety management procedures were in place and were implemented • an appropriate emergency response plan was in place.
To reduce greenhouse emissions to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that the planning and design processes included: • a structured assessment of the reduction of greenhouse emissions • studies to close any gaps in knowledge • the incorporation of new knowledge into the planning and design of the activity • a structured process to identify all legislative requirements. ■ Accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

Development and production

Activity

The actual configuration of onshore production facilities will be site-specific depending on the nature of the hydrocarbon produced, the size and location of the reservoir, existing infrastructure and local environmental conditions.

Production facilities could also be tied back via a pipeline to an offshore component. Facilities may range in size from several hectares to over 100 hectares. They may incorporate a range of activities and infrastructure for processing and storing the hydrocarbon and its by-products. Hydrocarbons may be exported by road, rail, ship or pipeline.

In remote areas, production facilities may incorporate workforce accommodation, power production, water sources, waste disposal facilities, and a range of supporting infrastructure.

Environmental issues

Project-specific risks should be identified during the planning phase. Environmental issues for development and production are usually assessed within an environmental approvals framework applicable to the jurisdiction within which it falls. Generally, potential environmental issues associated with development and production operations may include:

- disturbance to cultural heritage values
- erosion and changes to surface hydrology
- vegetation clearance
- introduction of weeds, pests or pathogens
- disturbance to wildlife
- impacts on land-uses including livestock
- low-level noise, vibration and light from facilities
- reduction in local air quality associated with planned emissions
- greenhouse gas emissions
- pollution due the discharge of wastes including produced water, solid wastes, NORM, chemicals fuel, hydrocarbons and other wastes
- hydrocarbon spills
- cross-flow between fluid strata
- reduction in visual amenity
- Socio-economic impacts
- Risks to the environment and public safety from the facilities.

Objectives	Example potential performance criteria
To avoid disturbance of sites of cultural heritage significance where practicable and reduce the risk of impacts to cultural heritage values to as low as reasonably practical and to an acceptable level.	■ There was appropriate cultural heritage consultation. ■ There was no unauthorised disturbance to sites of cultural heritage significance. Be able to demonstrate that: ● An approved Cultural Heritage Management Plan was in place; ● Management measures were implemented; and ● Appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures.
To reduce the impact on the beneficial uses of surface and groundwater, including ecosystem maintenance, to as low as reasonably practical and to an acceptable level.	■ Impacts to water quality were in accordance with legislative requirements and agreed levels. ■ Be able to demonstrate that: ● appropriate management measures were in place and were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified and the results communicated in accordance with agreed procedures.
To reduce impacts to vegetation, wildlife and wildlife habitats to acceptable levels and reduce the risk of impacts to as low as reasonably practical.	■ There was no unauthorised clearing of vegetation. ■ Be able to demonstrate that: ● appropriate management measures were in place and were implemented to minimise footprint and manage clearing activities ● appropriate rehabilitation measures were undertaken ● appropriate biological surveys were conducted to enable impacts to vegetation abundance, diversity, geographical spread and productivity to be identified and the results communicated in accordance with agreed procedures ● appropriate monitoring programs were in place to adequately assess the effectiveness of rehabilitation measures.
To reduce the risk of introduction (or spread) of weeds, pests and pathogens to as low as reasonably practical and to an acceptable level.	■ There were no weeds, pests and pathogens introduced (or spread). ■ Be able to demonstrate that: ● appropriate quarantine management measures were implemented in accordance with legislative requirements and agreed procedures ● appropriate monitoring programs were conducted to enable introductions to be identified, and the results communicated in accordance with agreed procedures ● any weeds, pests and pathogens detected were appropriately dealt with.
To reduce the impact of noise, light, odours, traffic and vibration on other land users to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ There were no complaints by other land users regarding amenity. ■ Be able to demonstrate that: ● appropriate management measures were in place to minimise impacts to land users, and these were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures ● appropriate management systems were in place to record complaints ● appropriate systems were in place to document consultation and communication with stakeholders.
To reduce planned emissions to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ Impacts were in accordance with legislative requirements and approved (predicted) levels. ■ Be able to demonstrate that: ● appropriate management measures were in place and were implemented ● appropriate monitoring programs were conducted to enable emissions to be recorded, impacts to be identified, and the results communicated in accordance with agreed procedures.

Objectives	Example potential performance criteria
To reduce the volume of waste produced to as low as reasonably practical and to an acceptable level. Ensure that relevant wastes are recycled where practicable or disposed of in appropriate facilities.	■ Be able demonstrate that: ● waste was managed in accordance with an approved waste management plan ● all solid wastes, chemicals and other wastes were disposed of or recycled at appropriate facilities in accordance with legislative requirements and agreed procedures.
To reduce the risk of any unplanned release of substances to land to as low as reasonably practical and to an acceptable level.	■ There were no reportable accidental losses of substances to land during drilling operations. ■ Be able demonstrate that: ● appropriate management procedures were in place and were implemented ● an appropriate emergency response plan was in place.
To reduce the risk of cross-flow between fluid strata to as low as reasonably practical and to acceptable levels.	■ There was no evidence of cross-flow. ■ Be able to demonstrate that: ● appropriate reservoir management procedures were in place and implemented ● an appropriate monitoring program was in place and implemented and appropriate records kept.
To reduce visual impacts of production operations to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ Be able to demonstrate that: ● areas of visual sensitivity were adequately addressed in the planning process ● appropriate measures were in place to reduce visual impact.
To reduce adverse socio-economic impacts to an acceptable level and reduce the risk of impacts to as low as reasonably practical.	■ There were no complaints by other land users regarding socio-economic impacts. ■ Be able to demonstrate that: ● an appropriate program of consultation and communication was undertaken ● appropriate management measures were in place to minimise socio-economic impacts, and these were implemented ● appropriate monitoring programs were conducted to enable impacts to be identified, and the results communicated in accordance with agreed procedures ● appropriate management systems were in place to record complaints and any necessary corrective measures were undertaken.
To reduce risks to public safety to as low as reasonably practical and to an acceptable level.	■ There were no accidents or incidents involving the public as a result of drilling operations. ■ Be able demonstrate that: ● appropriate safety management procedures were in place and were implemented ● an appropriate emergency response plan was in place.
To reduce greenhouse emissions to as low as reasonably practical and to an acceptable level.	■ Be able to demonstrate that the planning and design processes included: ● a structured assessment of the reduction of greenhouse emissions ● studies to close any gaps in knowledge ● the incorporation of new knowledge into the planning and design of the activity ● a structured process to identify all legislative requirements. Accountability was documented for all decisions taken with the potential to cause significant greenhouse emissions.

Decommissioning

Activity

It is a requirement of all petroleum developments that production facilities be removed at the end of their operating life, that the facilities be disposed of properly and that the site be made good. This is termed the decommissioning process. Decommissioning is controlled by federal and state government legislation, and is the responsibility of the operator.

Decommissioning is particularly important for offshore facilities, where a number of factors must be taken into consideration, including potential impacts on the environment, navigation safety, possible impact on the fishing industry and other marine users and operators, workforce and public safety, technical feasibility and cost.

International guidelines today prohibit instalment of an offshore facility unless its entire removal is feasible. Approval under Australia's environmental legislation (EPBC Act) includes consideration of the feasibility of removal, and development approval conditions usually require plans to be submitted for approval before decommissioning.

A number of decommissioning options are available to operators, depending on the structure, its location, physical factors and government regulations. The options include alternative use of the facility, leaving the facility in place, demolition in situ, partial removal, and full removal and disposal as an artificial reef, in deep water or onshore.

Environmental issues

The potential environmental issues associated with decommissioning generally can be identified in the planning stage. This process is guided by regulations and associated guidelines. Program-specific risks should be identified during the planning stage. Generally, potential environmental and other issues associated with decommissioning may include:

- potential impacts on the marine environment
- potential impacts on marine habitats and biodiversity
- potential impacts on areas of ecological significance
- pestoration of the environment disturbed by production and decommissioning
- management of chemicals and other wastes associated with the facility, including radioactive wastes
- recycling of materials in the facility
- possible use of the facility as an artificial reef
- disturbance to other marine resource users during and after decommissioning
- possible impact on fish stocks of partial removal or disposal at sea
- potential for any structure left on the seabed to enhance breeding/conservation of fish stocks
- method and technology used for removal or partial removal
- implications for navigation of any structures left in place or disposed on the seabed
- workplace and public safety during decommissioning
- maritime safety if structures are left in place, partially removed or disposed on the seabed
- possible impact on other facilities in the area
- possible impacts during and after decommissioning on recreational marine users
- proper disposal onshore
- stakeholder engagement and approval of the decommissioning plan.

Objectives	Example potential performance criteria
to reduce impacts to the marine environment to as low as reasonably practical and to an acceptable level.	Decommissioning was in accordance with approval conditions. ■ Potential impacts to the environment were minimised. ■ Be able demonstrate that: • there was a properly structured risk assessment of the decommissioning activities • appropriate management procedures were in place to minimise impacts and these were implemented • there were no breaches of legislative requirements • there were no unplanned incidents during decommissioning • appropriate monitoring programs were conducted to enable any impacts to be identified, and that results were communicated in accordance with agreed procedures • the facility was deconstructed or removed and disposed of according to approved conditions.
To restore the seabed, or other disturbed area, to its original condition or to reduce disturbance to as low as reasonably practical and to an acceptable level.	Site restoration measures were planned and approved before decommissioning started. ■ Making good the site did not impact adversely on marine habitats, fish stocks or other seabed features. ■ A site inspection after decommissioning confirmed restoration objectives were met. ■ Be able to demonstrate: • appropriate management measured were in place and were implemented • decommissioning was monitored , a post-decommissioning inspection was conducted and the final outcome recorded and communicated • if the structure, or part of it, is left in situ, this was done according to approved conditions.
To reduce the risk of release of chemicals or other wastes into the marine environment to as low as reasonably practical and to an acceptable level.	The facility was inspected and all chemicals and other wastes were removed or secured before decommissioning to prevent release into the marine environment. ■ All chemicals and other wastes removed were properly disposed onshore. ■ There was no accidental loss of substances to sea during decommissioning. ■ Be able demonstrate that: • appropriate management procedures were in place and were implemented • decommissioning proceeded according to plans and all actions were documented • the procedure was properly monitored and recorded • all chemicals and other wastes were properly secured during de-commissioning, or removed and safely disposed ashore.

Objectives	Example potential performance criteria
To ensure there is no on-going risk to navigation or other marine operators or users, or that the risk is as low as reasonably practical and to an acceptable level.	If the facility was left in place, partly removed or disposed at sea, this was done according to approved conditions. ■ Appropriate authorities and organisations were made aware of any potential navigation risk after decommissioning. ■ Plans are in place to monitor the situation ■ Be able demonstrate that: ● appropriate management procedures were in place and implemented ● there were proper communications with appropriate marine authorities and organisations ● part removal or at-sea disposal was completed according to approved conditions and guidelines, and properly recorded ● there were no breaches of legislative requirements.
To ensure stakeholders were fully aware of decommissioning and approved decommissioning plans.	Decommissioning planning included communication with all appropriate stakeholders. ■ Stakeholder engagement was documented and recorded. ■ Be able to demonstrate that: ● appropriate management procedures were in place and are implemented ● guidelines were followed and there were no breaches of legislative requirements ● stakeholders were aware of de-commissioning options and the benefits of the chosen option ● stakeholders were kept informed at all stages during decommissioning planning and execution ● any stakeholder concerns were recorded and taken into account during decommissioning planning, to the extent reasonably practical.

ABBREVIATIONS

APPEA	Australian Petroleum Production & Exploration Association
MCMPR	The Ministerial Council on Minerals and Petroleum Resources
NORM	Naturally Occurring Radioactive Material

REFERENCES

APPEA (2003) *The Principles of Conduct*. Australian Petroleum Production and Exploration Association, Canberra.

APPEA (1996) *Code of Environmental Practice*. Australian Petroleum Production and Exploration Association, Canberra.

AS/NZS (2005) *Environmental Management Standards AS/NZS ISO 14000* Set: 2005. Standards Australia.

E&P Forum and UNEP (1997) *Environmental Management in Oil and Gas Exploration and Production*. Joint UNEP & E&P Forum Guidelines, UNEP Technical Publication PM35.

IADC (2006) *Health, Safety and Environmental Case Guideline for Mobile Offshore Drilling Units Issue 3.3* (Final). International Association of Drilling Contractors, Houston.

MCMPR (2005) *Principles for Engagement with Communities and Stakeholders*. Department of Industry Tourism and Resources, Canberra.

Swan JM, Neff JM and Young PC (Eds) (1994) *The Environmental Implications of Offshore Oil and Gas Development in Australia – the Findings of an Independent Scientific Rreview*. Australian Petroleum Exploration Association Sydney, pp 123–206.

United Nations (1992) *Agenda 21, Report of the United Nations Conference on Environment and Development*. Rio de Janeiro, 3–14 June 1992.

THE AUSTRALIAN PETROLEUM PRODUCTION AND EXPLORATION ASSOCIATION

PRINCIPLES OF CONDUCT

APPEA

AUSTRALIAN PETROLEUM PRODUCTION & EXPLORATION ASSOCIATION

APPEA

Head Office
APPEA Limited
Level 10
60 Marcus Clarke St
Canberra, ACT 2600
T 02 6247 0960
F 02 6247 0548
appea@appea.com.au

Perth Office
APPEA Limited
Level 1
190 St George's Tce
Perth, WA 6000
T 08 9321 9775
F 08 9321 9778
perth@appea.com.au

Brisbane Office
APPEA Limited
Level
320 Adelaide St
Brisbane, Qld 4000
T 07 3211 8300
brisbane@appea.com.au

www.appea.com.au

ABN 44 000 292 713

Principles of Conduct

The Australian Petroleum Production and Exploration Association (APPEA) and its member companies (**APPEA Members**) have agreed to this set of Principles of Conduct (**Principles**) to communicate and explain our shared core values to industry, regulators, and the communities in which they operate.

The Principles of Conduct provide the basis for achieving the APPEA mission of a legislative, administrative, economic and social framework which efficiently and effectively facilitates safe, environmentally responsible, socially responsible and profitable oil and gas exploration, development and production.

APPEA members will continuously seek opportunities for improvement in our business practices and our economic, health, safety, environment and social performance. In striving to achieve this, APPEA and its members endorse the following nine Principles of Conduct:

1. Ethical and responsible business practices.
2. Sustainable development considerations integrated into company decision making.
3. Foster economic growth and business development, generate government revenue, provide commercial returns to the industry and contribute to the wealth generated by Australia's natural resource base.
4. Health, safety, environmental and community risk management strategies that are based on sound science and effective communication.
5. Continuously seek opportunities to improve health, safety and environmental performance in addressing risks posed by our operations to employees, contractors, the public and the environment.
6. Contribute to the conservation of biodiversity and protection of the environment through responsible management of our operations and their impacts.
7. Foster economic and social development of the communities in which we operate.
8. Respect the rights and dignity of our workforce, and deal fairly with our workforce, suppliers and the communities in which we operate.
9. Open and effective engagement with the communities in which we operate.

Associated explanatory notes to APPEA's Principles of Conduct

The Australian Petroleum Production and Exploration Association and its members have developed Principles of Conduct to better communicate and explain our shared core values to industry, regulators, and the communities in which we operate. While meeting the Principles is a commitment by members, the Principles do not prescribe how APPEA Members are to specifically meet this commitment. It is recognised that many factors, such as type, scale and location of each individual operation create unique conditions requiring a specific application of the Principles to achieve the most practical outcome.

It is not intended that the Principles impose standards or tell APPEA Members how to perform, but instead the Principles are aimed at influencing values and behaviour. The strength in the Principles lies in their voluntary nature and in the flexibility they offer APPEA Members. The Principles provide an opportunity for Australia's petroleum industry to communicate a consistent approach to these sustainable development issues across all Australian jurisdictions.

1 Ethical and responsible business practices

The way APPEA Members conduct their business is as important as the results themselves. APPEA Members expect everyone — directors, officers, employees and suppliers acting on our behalf — to act in an ethical manner. APPEA Members will make ethical business practice and good corporate governance a pervasive feature of company operations.

This includes complying with the requirements of all applicable laws and regulations, while aspiring to higher standards and applying responsible standards where laws and regulations do not currently exist. APPEA Members will work actively with governments, industry and other stakeholders to achieve appropriate and effective public policy, laws, regulations and procedures that facilitate the contribution of the industry to the sustainable development of Australia.

For further guidance, other important documents include:

- *Corporations Act 2001.*
- Rules of accepted accounting best practices.
- Rules and Guidelines of the Australian Stock Exchange.

2 Sustainable development considerations integrated into company decision making

The World Business Council for Sustainable Development defines sustainable development as:

"... forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs."

APPEA and its members recognise this globally accepted concept of sustainable development, developed from Gro Harlem Brundtland's report — *Our Common Future (1987)*. This concept is now well established and globally accepted across commercial sectors and communities.

Australia's oil and gas industry has a great capacity to contribute significantly to the sustainable development of Australia, helping to produce more affordable, accessible and increasingly cleaner energy than ever before in ways that are responsible and ethical and within acceptable limits of environmental impact. APPEA Members consider economic, social, safety and environmental issues in decision making, based on sustainable development principles.

In implementing sustainable development considerations APPEA Members' underlying philosophy is one of continuous improvement; protecting the health and safety of the industry workforce and the communities in which the industry operates; reducing the industry's ecological footprint; increasing the industry's contribution to the national community; and enhancing the economic prosperity of the nation.

For further guidance, other important documents include:

- World Commission on Environment and Development (WCED). *Our common future*. Oxford: Oxford University Press, 1987.
- The World Business Council for Sustainable Development — www.wbcsd.ch.

3 Foster economic growth and business development, generate government revenue, provide commercial returns to the industry and contribute to the wealth generated by Australia's natural resource base.

APPEA Members make a significant contribution to both the Australian economy and the standard of living of all Australians. The industry is directly responsible for the provision of a reliable and competitively priced source of energy that facilitates domestic growth and allows other Australian industries to remain internationally competitive. Domestic production of petroleum also allows Australia to generate valuable export income and replace imports of petroleum and products. It also helps avoid a dependence on fuel supplies from other regions of the world. In addition to assisting the performance of the Australian economy, the industry makes direct and valuable contributions to all levels of government in Australia through company tax, resource taxes and payroll taxes.

4 Health, safety, environmental and community risk management strategies that are based on sound science and effective communication

APPEA Members are committed to risk management practices based on sound science and advice to reduce the risk of adverse health, safety, environmental and social impacts of the industry to as low as reasonably practicable. Good risk management requires consultation with experts and affected stakeholders, ensuring that stakeholders are informed of significant hazards that may affect them.

APPEA and its members make a substantial contribution to improving the understanding of the industry's impacts by supporting research into significant risks associated with the activities of the industry to support decision making. This research into impacts of the industry has enhanced government databases and baseline data and has significantly improved our broad scientific understanding of the unique Australian environment.

Good risk management strategies periodically assess the risk management measures in place to further develop and improve effective procedures to deal with any reasonably foreseeable incidents.

Good risk management also includes reviewing the training and instructions provided to the industry's workforce to ensure it has the capacity to understand and fulfil its responsibilities with due regard for health, safety and the environment.

For further guidance, other important documents include:

- APPEA's Health and Safety Policy.
- APPEA's Code of Environmental Practice.
- APPEA's Environment Policy.
- APPEA's Greenhouse Challenge Cooperative Agreement.
- Relevant legislative requirements — see www.industry.gov.au for a comprehensive list of Commonwealth laws and links to all other jurisdictions.

5 Continuously seek opportunities to improve health, safety and environmental performance in addressing risks posed by our operations to employees, contractors, the public and the environment

The health, safety and environmental performance of the industry reflects continuous improvement in response to changing community expectations. Individual companies are judged by the performance of the industry as a whole, both in Australia and overseas. APPEA Members strive to be leaders in health, safety, and environmental management (including application of technologies and building partnerships with key stakeholders)in order to meet the community's future expectations while meeting their energy needs.

The health and safety of every employee, contractor, customer and community member is central to the way the industry operates. The goal of the industry is to work in such a way that no one is injured. Recognising that APPEA Members will not support any decision that compromises safety for the sake of any other business objective, the overriding philosophy is that no task is so important that it cannot be done safely.

APPEA Members continue to seek opportunities to identify new measures and practices to eliminate injury and disease and to reduce the environmental and associated social impacts that may arise from the industry's operations to as low as reasonably practicable. Seeking opportunities to identify areas for improvement includes periodic auditing of the industry's performance; the use of key performance indicators to track the industry's progress over time; benchmarking the industry's operations against our peers and other industry sectors; supporting innovation and the development of new technologies to assist the industry to improve; as well as evaluating the results from monitoring and scientific investigations.

The industry also encourages a reporting culture amongst its entire workforce that fosters the reporting of any incident that has health, safety, or environmental implications. Investigation of incidents can identify root causes and allow the industry to share the results amongst the industry and the broader community in order to prevent the occurrence of similar incidents and further improve the industry's performance.

For further guidance, other important documents include:

- APPEA's Health and Safety Policy.
- APPEA's Code of Environmental Practice.
- APPEA's Environment Policy.
- APPEA's Greenhouse Challenge Cooperative Agreement.
- Relevant legislative requirements — see www.industry.gov.au for a comprehensive list of Commonwealth laws and links to all other jurisdictions.

6 Contribute to the conservation of biodiversity and protection of the environment through responsible management of our operations and their impacts.

APPEA Members recognise maintenance of biodiversity and protection of the environment as critical elements of sustainable development. The industry strives to ensure that biodiversity is not unduly threatened by its activities through commitment to mitigation strategies.

These strategies are directed at minimising the industry's ecological footprint and take particular care to protect threatened and endangered species and related critical habitats.

The industry is a strong supporter of the conservation of biodiversity and protection of the environment. The industry's commitment to responsible environmental management is stated in APPEA's Code of Environmental Practice, which provides a set of recommended minimum standards for industry activities. Responsibly balancing considerations of environment, community, resource use and economics through all phases of a project is enshrined within the Code of Environmental Practice.

APPEA Members must determine the specific needs of their own operations, including relevant regulatory requirements, and develop suitable environmental management systems and practices to prevent and control the potential for environmental impacts. Self-determination of how best to implement the elements of the Code of Environmental Practice allows APPEA Members to rapidly adopt new technologies and seek opportunities for continuous improvement of management practices.

Working with governments and other stakeholders to ensure integrated approaches to land/marine-use planning will further improve our ability to contribute to the conservation of biodiversity and protection of the environment.

For further guidance, other important documents include:

- APPEA's Code of Environmental Practice.
- APPEA's Environment Policy.
- APPEA's Greenhouse Challenge Cooperative Agreement.
- Relevant legislative requirements — see www.industry.gov.au for a comprehensive list of Commonwealth laws and links to all other jurisdictions.

7 Foster economic and social development of the communities in which we operate.

APPEA Members strive to build mutually beneficial relationships within all of the communities in which they operate.

APPEA Members, work to maximise local Australian industry participation in industry operations. They seek to ensure local capabilities are maximised through effective business relationships and through offering local suppliers full and fair opportunity to tender for industry projects. The industry considers that decisions on provision of services should take into account the capacity of suppliers to provide service over the whole of the life of a project and that business relationships should be developed so that this whole of life service is provided.

Building effective relationships with local communities also means ensuring government and community participation in the formulation of exploration and development strategies. Public consultation processes are undertaken at all stages of project development and implementation. These processes manage social impacts by taking into account changing circumstances and supporting affected communities through engagement with all parties at the earliest stage practicable. Visible management structures should be established to ensure that all stakeholders have equitable and culturally appropriate access to the process.

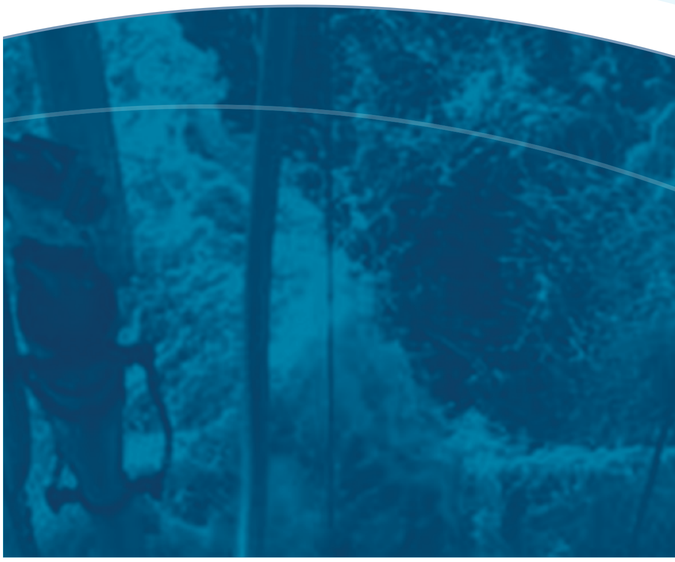
For further guidance, other important documents include:

- APPEA Australian Industry Participation Code.
- Australian Competitive Energy Best Practice Guide to Maximising Australian Industry Participation in Petroleum Exploration and Production.
- Government policy statements on Australian Industry Participation Plans.

8 Respect the rights and dignity of our workforce, and deal fairly with our workforce, suppliers and the communities in which we operate

The exceptional quality of our workforce is a valuable competitive edge. To build on this advantage, APPEA Members strive to hire and retain the most qualified people available and maximise their opportunities for success through training and development. APPEA Members are committed to developing training opportunities for its workforce and the communities in which the industry operates and to standardizing operational practices so as to allow its workers maximum employment flexibility and job security.

APPEA Members are committed to maintaining a safe work environment, enriched by diversity and characterized by open communication, trust and fair treatment. APPEA Members respect all variety of cultures, customs and values at its operational sites and in industry dealings with others, and have a range of measures in place to prevent discrimination and harassment in the work place.



9 Open and effective engagement with the communities in which we operate

APPEA Members believe that open and effective engagement with the communities in which they operate is an important process to establish and maintain mutually beneficial relationships with all stakeholders. Effective, well managed, open consultation processes provide governments, stakeholders and the general public with confidence in the organisation and management processes of APPEA Members while minimising potential delays and therefore avoidable costs.

The type, timing and extent of effective community engagement will vary, depending on the level of public interest in a particular activity.

APPEA Members recognise the importance of providing timely and accurate information on activities to all relevant stakeholders. Effective engagement with communities communicates the likely impacts to stakeholders, gains an understanding of community values, concerns and interests; and recognises the importance of community engagement as an ongoing process. APPEA Members are encouraged to publicly report on sustainable development and APPEA will continue to report on the health, safety, environmental and social performance of the industry as a whole.

ince 1959, the Austr
etroleum Production
xploration Associati
APPEA) has been the
ational body repres
he collective interest
he upstream oil and
xploration and proc
ndustry. The associat
as more than 68 full
member companies t
xplore for and prod
ustralia's oil and ga
esources. Accounting
n estimated 98 per c
f the nation's petrol
roduction. In additio
PPEA also represent

www.appea.com.au

THE AUSTRALIAN PETROLEUM PRODUCTION & EXPLORATION ASSOCIATION

APPEA

Head Office
APPEA Limited
Level 10
60 Marcus Clarke St
Canberra, ACT 2600
T 02 6247 0960
F 02 6247 0548
appea@appea.com.au

Perth Office
APPEA Limited
Level 1
190 St George's Tce
Perth, WA 6000
T 08 9321 9775
F 08 9321 9778
perth@appea.com.au

Brisbane Office
APPEA Limited
Level 3
320 Adelaide St
Brisbane, Qld 4000
T 07 3211 8300
brisbane@appea.com.au