ATTACHMENT

NSW Legislative Council General Purpose Standing Committee No. 5 Inquiry into Coal Seam Gas: APPEA Answers to Questions on Notice

1. Table a copy of the Carnegie Mellon study.

Question

The Hon. JEREMY BUCKINGHAM: Which studies, Mr Wilkinson?

Mr WILKINSON: The CSIRO, the International Energy Agency and the Australian Energy Market Operator.

The Hon. JEREMY BUCKINGHAM: Are you saying they make reference in those—

CHAIR: Allow the witness to answer the question and then you can ask another question.

Mr WILKINSON: The material difference there would not change the story with regard to fugitive emissions. However, I can refer you to a Carnegie Mellon study, which looked at total emissions. I can make that available to you. When they compared conventional gas to, in this case, shale gas, they found only a 3 per cent increase relative to life cycle emissions.

The Hon. JEREMY BUCKINGHAM: A 3 per cent increase?

Mr WILKINSON: Over conventional gas.

The Hon. JEREMY BUCKINGHAM: What was the conventional gas?

CHAIR: Could you table that study or take that on notice?

Mr WILKINSON: Yes.

Answer

Attached is a copy of the paper referred to: *Life cycle greenhouse gas emissions of Marcellus shale gas, Mohan Jiang, W Michael Griffin, Chris Hendrickson, Paulina Jaramillo, Jeanne VanBriesen and Aranya Venkatesh,5 August 2011.*

The paper is also available at: http://iopscience.iop.org/1748-9326/6/3/034014/pdf/1748-9326_6_3_034014.pdf.

2. Number of member land access agreements.

Question

The Hon. JEREMY BUCKINGHAM: Have your members signed more agreements last year, compared to this year?

Would you be prepared to table a list of the number of access agreements that the bodies that you represent have been able to sign?

Mr WILKINSON: I can put a request to the members to provide that data to me but I am unable to directly address it myself.

Answer

This information is held by our members and the question should be put to them directly.

3. Table ABARES report and Productivity Commission Reports

Question

Mr WILKINSON: …The other thing I would like to point out is in relation to, not just the footprint on the land, which is one or two per cent, but I would like to refer to a couple of reports that address the issue of global food security. A report from the Australian Bureau of Agricultural and Resource Economics and Sciences states that a number of things affect food productivity, one being the poor prices our farmers get. They indicate from their analysis that if the price of food goes up, productivity will go up dramatically and the report states that 10 to 40 per cent of the post harvest is lost from waste. For me, those are the areas to focus on in terms of bringing food productivity up, not the one or two per cent footprint that coal seam gas may have on the land.

The technology of coal seam gas is advancing such that we are able to move wells around and be more selective about what land we operate on. Ever decreasing, as technology improves, is the impact on the land itself. Finally, I note under "Agricultural Area" in a report from the Productivity Commission, that as much as 45 per cent of broadacre farmers have off-farm wages coming in. So these are difficult times for agriculture with almost one half of the broadacre farms having wages and salaries coming in and that is something that coal seam gas can definitely help with, as we increase employment opportunities in those areas.

CHAIR: Mr Wilkinson, would you be able to provide the Committee with the references that you have quoted there on notice?

Mr WILKINSON: Certainly.

Answer

A copy of both reports is attached.

The ABARES report is available at:
http://adl.brs.gov.au/data/warehouse/pe_abares99010538/SEI1_2011GlobalFoodSecurityReport.pdf.

The Productivity Commission report is available at:
http://www.pc.gov.au/__data/assets/pdf_file/0018/8361/agriculture.pdf.

4. Number of APPEA members

Question

CHAIR: How many members does the Australian Petroleum Production and Exploration Association have? You can take the question on notice.

Mr PAULL: I can take it on notice, but it is approaching 100 full members of ~~coal~~ oil and gas companies producing and/or exploring for oil and gas in Australia, and I think there are 250 or more associate members, and those are bodies providing services to the industry.

Answer

APPEA has 90 full members and 250 associate members at Wednesday 18 January 2012, a full listing is available on the APPEA website: www.appea.com.au.

Please also note the correction above to the transcript.

5. Table copies of Codes of Practice

Question

CHAIR: Do you have a code of practice for your members?

Mr WILKINSON: There is a code of practice for various parts of the industry, for example, land access.

Mr PAULL: Is there an environmental code of practice?

CHAIR: Perhaps you could provide on notice a list of what those codes cover? Better still, would you be able to provide the Committee with documentation on your codes of practice?

Mr WILKINSON: Yes.

Answer

Attached are copies of:

- APPEA Code of Environmental Practice, October 2008
- APPEA Principles of Conduct, September 2003

Life cycle greenhouse gas emissions of Marcellus shale gas

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(http://iopscience.iop.org/1748-9326/6/3/034014)

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Life cycle greenhouse gas emissions of Marcellus shale gas

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Abstract
This study estimates the life cycle greenhouse gas (GHG) emissions from the production of Marcellus shale natural gas and compares its emissions with national average US natural gas emissions produced in the year 2008, prior to any significant Marcellus shale development. We estimate that the development and completion of a typical Marcellus shale well results in roughly 5500 t of carbon dioxide equivalent emissions or about 1.8 g CO_2e/MJ of gas produced, assuming conservative estimates of the production lifetime of a typical well. This represents an 11% increase in GHG emissions relative to average domestic gas (excluding combustion) and a 3% increase relative to the life cycle emissions when combustion is included. The life cycle GHG emissions of Marcellus shale natural gas are estimated to be 63–75 g CO_2e/MJ of gas produced with an average of 68 g CO_2e/MJ of gas produced. Marcellus shale natural gas GHG emissions are comparable to those of imported liquefied natural gas. Natural gas from the Marcellus shale has generally lower life cycle GHG emissions than coal for production of electricity in the absence of any effective carbon capture and storage processes, by 20–50% depending upon plant efficiencies and natural gas emissions variability. There is significant uncertainty in our Marcellus shale GHG emission estimates due to eventual production volumes and variability in flaring, construction and transportation.

Keywords: life cycle assessment, greenhouse gases, Marcellus shale, natural gas

S Online supplementary data available from stacks.iop.org/ERL/6/034014/mmedia

1. Introduction

Marcellus shale is a rapidly developing new source of US domestic natural gas. The Appalachian Basin Marcellus shale extends from southern New York through the western portion of Pennsylvania and into the eastern half of Ohio and northern West Virginia (Kargbo *et al* 2010). The estimated basin area is between 140 000 and 250 000 km^2 (Kargbo *et al* 2010), and has a depth ranging from 1200 to 2600 m (US DOE 2009). The shale seam's net thickness ranges from 15 to 60 m (US DOE 2009) and is generally thicker from west to east (Hill *et al* 2004). Figure 1 shows the location of the Marcellus and other shale gas formations in the continental United States.

Shale gas has become an important component of the current US natural gas production mix. In 2009, shale gas was 16% of the 21 trillion cubic feet (Tcf) or 600 million cubic meters (Mm^3) total dry gas produced (US EIA 2011a, 2011b). In 2035, the EIA expects the share to increase to 47% (12 Tcf or 340 Mm^3) of total gas production. The prospect of rapid shale gas development has resulted in interest in expanding

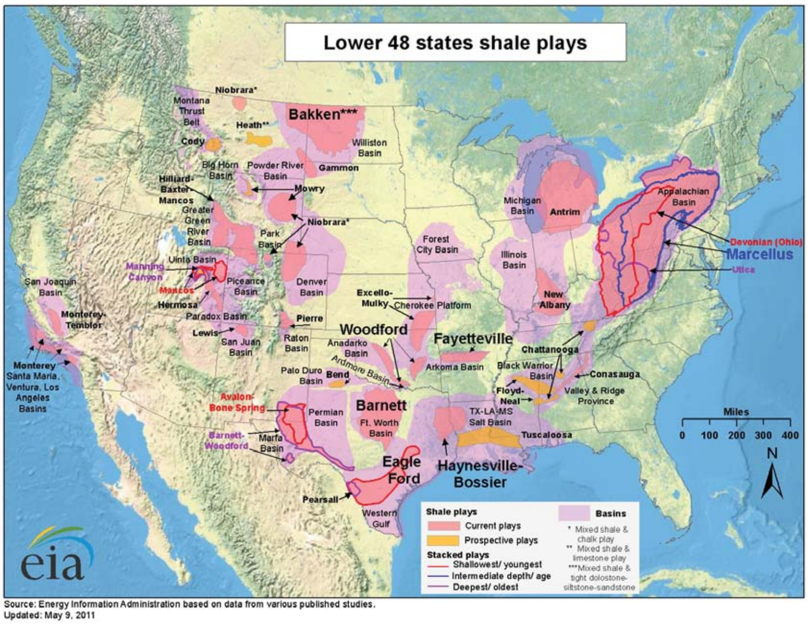

Figure 1. Shale gas plays and basins in the 48 states (source: US Energy Information Administration 2011a, available at http://www.eia.gov/oil_gas/rpd/shale_gas.jpg).

natural gas use including increased natural gas fired electricity generation, use as an alternative transportation fuel, and even exporting as liquefied natural gas. To date most shale gas activity has been in the Barnett shale in Texas. However, the immense potential of the Marcellus shale has stimulated increased attention. The shale play has an estimated gas-in-place of 1500 Tcf or 42 000 Mm^3, of which 262–500 Tcf or 7400–14 000 Mm^3 are thought to be recoverable (Hill *et al* 2004, US DOE 2009).

Advancements in horizontal drilling and hydraulic fracturing, demonstrated successfully in the Barnett shale and first applied in the Marcellus shale in 2004, have enabled the recovery of economical levels of Marcellus shale gas. After vertical drilling reaches the depth of the shale, the shale formation is penetrated horizontally with lateral lengths extending thousands of feet to ensure maximum contact with the gas-bearing seam. Hydraulic fracturing is then used to increase permeability that in turn increases the gas flow.

In this study, life cycle greenhouse gas (GHG) emissions associated with the Marcellus shale gas production are estimated. The difference between GHG emissions of natural gas production from unconventional Marcellus gas wells and average domestic wells is considered to help determine the environmental impacts of the development of shale gas resources. The results of this analysis are compared with life cycle GHG emissions of average domestic natural gas pre-Marcellus and imported liquefied natural gas. In addition domestic coal and Marcellus shale for electricity generation are compared. Other environmental issues may also be of concern in the Marcellus shale development, including disruption of natural habitats, the use of water and creation of wastewater as well as the impacts of truck transport in rural areas. However these environmental issues are outside the scope of our analysis and are not addressed in this paper.

In estimating GHG emissions, we include GHG emissions of carbon dioxide, methane and nitrous oxide. We converted the GHG emissions to carbon dioxide equivalents according to the global warming potential (GWP) factors reported by IPCC. We use the 100-year GWP factor, in which methane has a global warming potential (GWP) 25 times higher than carbon dioxide (IPCC 2007).

2. Marcellus shale gas analysis boundaries and functional unit

The boundary of our analysis and the major process steps included in our estimates are shown in figure 2. Final life cycle emission estimates are reported in grams of carbon dioxide equivalent emissions per megajoule of natural gas (g CO_2e/MJ) produced. Each of the individual processes in the natural gas life cycle has an associated upstream supply chain and is included in this study to provide a full assessment of GHG emissions associated with Marcellus shale gas. The sources of GHG emissions considered in the LCA include: emissions from the production and transportation of material involved in the well development activities (such as trucking water); emissions from fuel consumption for powering the drilling and fracturing equipment; methane leaks and fuel combustion emissions associated with gas production, processing, transmission, distribution, and natural gas combustion.

The life cycle of Marcellus shale natural gas begins with a ‘preproduction phase’ that includes the well site investigation, preparation of the well pad including grading and construction of the well pad and access roads, drilling, hydraulic fracturing, and well completion (Soeder and Kappel 2009). After this preproduction phase is completed, the well becomes operational and starts producing natural gas. This natural gas can require additional processing to remove water, CO_2 and/or

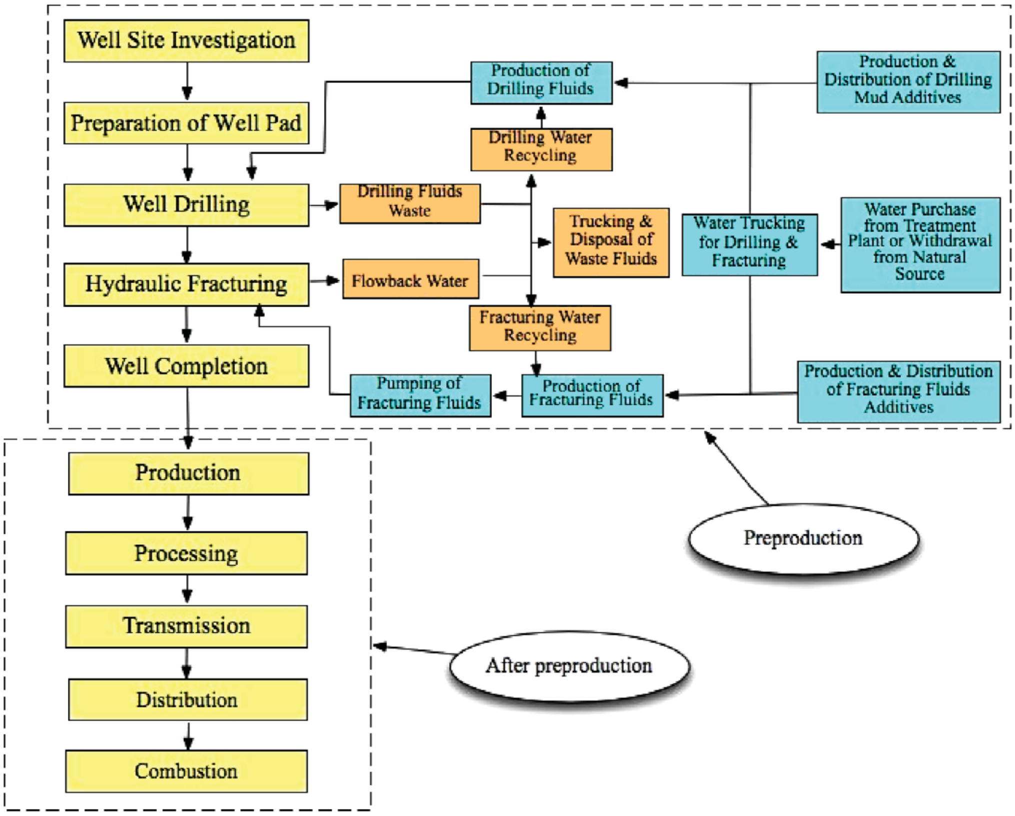

Figure 2. Analysis boundaries and gas production processes.

natural gas liquids before it enters the natural gas transmission and distribution system, which delivers it to final end users. For this work we assume that the GHG emissions for production, transmission, distribution and combustion of Marcellus shale natural gas are similar to average domestic gas sources as estimated by Jaramillo *et al* (2007) and further developed and updated by Venkatesh *et al* (2011).

Finally, natural gas has many current and potential uses including electricity generation, chemical feedstock, and as a transportation fuel. Modeling these uses allows comparisons of different primary energy sources. Here we model its use for power generation since it is the largest single use of natural gas in the US (US EIA 2011a, 2011b).

As previously mentioned, this study integrates GHG emissions from the life cycle of water associated with Marcellus shale gas production. Large amounts of water are consumed in the drilling and hydraulic fracturing processes (preproduction phase). Hydraulic fracturing uses fluid pressure to fracture the surrounding shale. The fracturing fluid consists of water mixed with a number of additives necessary to successfully fracture the shale seam. The source of the water varies and can be surface or ground water, purchased from a local public water supplier, or reused fracturing water. In this study we assume 45% of the water is reused on site and the original sources are surface water (50%) and purchased from a local water treatment plant (50%). Regardless of the water source used to produce the hydraulic fracturing fluid, trucks transport the water for impoundment at the well pad. In addition, flowback water (hydraulic fracturing fluid that returns to the surface) and produced water must be trucked to the final disposal site. This water is assumed to be disposed of via deep well injection. A detailed description of the method and data sources used to estimate the GHG emissions associated with all these stages is presented in section 3.

Marcellus shale gas production is in its infancy. Thus, industry practice is evolving and even single well longevity is unknown. Assumptions related to production rates and ultimate recovery have considerable uncertainty. Below, we include a sensitivity analysis for a wide range of inputs parameters.

This study does not consider any GHG emissions outside of the Marcellus shale gas preproduction and production processes. Natural processes or development actions such as hydraulic fracturing might lead to emissions of the shale gas external to a well, particularly in the case of poorly installed well casings (Osborn *et al* 2011). Any such external leaks are not included in this study.

3. Methods for calculating life cycle greenhouse gas emissions

Our study used a hybrid combination of process activity emission estimates and economic input–output life cycle assessment estimates to estimate the preproduction GHG emission estimates (Hendrickson *et al* 2006, CMU GDI 2010). Emissions from production, processing and transport were adapted from the literature. We include emissions estimates based on different data sources and reasonable

Table 1. Greenhouse gas estimation approaches and data sources.

Process	Estimation approaches	Data sources
Preparation of Well Pad:		
Vegetation clearing	Estimated area cleared multiplied by vegetative carbon storage to obtain carbon loss due to land use change	NY DEC (2009), Tilman *et al* (2006)
Well pad construction	Detailed cost estimate and EIO-LCA model	RSMeans (2005), CMU GDI (2010)
Well drilling:		
Drilling energy consumption	(1) Energy required and emission factor, and (2) cost estimate and EIO-LCA model	Harper (2008), Sheehan *et al* (2000), CMU GDI (2010)
Drilling mud production	(1) Cost estimate and EIO-LCA and (2) emission factors multiplied by quantity.	Shaker (2005), PRé Consultants (2007), CMU GDI (2010)
Drilling water consumption	Trucking emissions plus water treatment emissions multiplied by quantity	Wang and Santini (2009), URS Corporation (2010), PA DEP (2010), Stokes and Horvath (2006)
Hydraulic fracturing:		
Pumping	Pumping energy multiplied by emission factor	URS Corporation (2010), Kargbo *et al* (2010), Currie and Stelle (2010), Sheehan *et al* (2000)
Additives production	Additive quantities cost and EIO-LCA model	URS Corporation (2010), CMU GDI (2010)
Water consumption	Trucking emissions	Wang and Santini (2009), URS Corporation (2010), Stokes and Horvath (2006), PA DEP (2010)
Well completion:	If flaring, gas flow emission factor multiplied by flaring time	NY DEC (2009), PA DEP (2010)
Wastewater disposal:		
Deep well injection	Deep well injection costs and EIO-LCA model	US ACE (2006), CMU GDI (2010)
Production, processing, transmission and storage, and combustion	Assumed comparable to national average	Venkatesh *et al* (2011)

ranges of process parameters. Table 1 summarizes estimation approaches used in this study, while calculation details appear in the supplementary information (available at stacks.iop.org/ERL/6/034014/mmedia).

In section 3.1, we report point estimates of GHG emissions for a base case. In section 5, we report range estimates and consider the sensitivity of point estimates to particular assumptions. Table 2 summarizes important parameter assumptions and possible ranges. Uniform or triangular distributions are assigned to these parameters based on whether we had two (uniform) or three (triangular) data points. When more data was available, parameters of probability distributions that best fit the data were estimated. A Monte Carlo analysis was performed using these distributions, to estimate the emissions from the various activities considered in our life cycle model.

3.1. Emissions from Marcellus shale gas preproduction

Horizontal wells are drilled on a multi-well pad to achieve higher cost-effectiveness. It is reported that a Marcellus well pad might have as few as one well per pad and as many as 16, but more typically 6–8 (ICF International 2009, NY DEC 2009, Currie and Stelle 2010). As a base case scenario, we chose to analyze the typical pad with six wells, each producing 2.7 Bcf (3.0×10^9 MJ), representing an average of 0.3 MMcf per day of gas for 25 years. Other production estimates are higher. EQT (2011), for example, provides a production estimate of 7.3 Bcf (8.1×10^9 MJ) and Range Resources at 4.4 Bcf (4.9×10^9 MJ) (Ventura 2009). Within the LCA framework the impacts are distributed across the total volume of gas produced during the lifetime of the well. Thus, the choice of using the low end ultimate recovery as the base case should be considered conservative. With Marcellus shale gas production currently in its infancy, the average production characteristics have significant uncertainty, so we perform an

Table 2. Parameter assumptions and ranges. (Note: sources for base case and range values are in table 1 and discussed in the supplementary material (available at stacks.iop.org/ERL/6/034014/mmedia).)

Parameter	Base case	Range
Area of access road (acres)	1.43	0.1–2.75
Wells per pad (number)	6	1–16
Area of well pad (acres)	5	2–6
Vertical drilling depth (ft)	8500	7000–10 000
Horizontal drilling length (ft)	4000	2000–6000
Fracturing water (MMgal/well)	4	2–6
Flowback fraction (%)	37.5	35–40
Recycling fraction (%)	45	30–60
Trucking distance between well site and water source (miles)	5	0–10
Trucking distance between well site and deep well injection facility (miles)	80	3–280
Well completion time with collection system in place (h)	18	12–24
Well completion time without collection system in place (days)	9.5	4–15
Fraction of flaring (%)	76	51–100
Initial 30 day gas flow rate (MMscf/day)	4.1	0.7–10
Average well production rate (MMscf/day)	0.3	0.3–10
Well lifetime (years)	25	5–25

extensive sensitivity analysis over a range of flow rates and well lifetimes, as discussed below.

The EIO-LCA (CMU GDI 2010) model was used to estimate GHG emissions from the construction of the access road and the multi-well pad. These costs were estimated using the utility price cost estimation method (RSMeans 2005). The size of an average Marcellus well pad is reported as being between 2 and 6 acres and typically between 4 and 5 acres (16 000 and 20 000 m^2) during drilling and fracturing phase (NY DEC 2009, Columbia University 2009). The costs of constructing this pad are estimated to be \$3.0–\$3.3 million per well pad in 2002 dollars (see the supplementary information available at stacks.iop.org/ERL/6/034014/mmedia for detail). Using these costs as input, GHG emissions associated with well pad construction are estimated with the EIO-LCA (CMU GDI 2010) model.

Greenhouse gas emissions associated with drilling operations were calculated by two methods; (1) using the drilling energy intensity (table 1) and the life cycle diesel engine emissions factor of 635 g CO_2e per hp–hr output (Sheehan *et al* 2000), and (2) using drilling cost data and the EIO-LCA model (CMU GDI 2010). The EIA estimated the average drilling cost for natural gas wells in 2002 to be \$176 per foot (including the cost for drilling and equipping the wells and for surface producing facilities) (US EIA 2008). Emissions associated with the production of the drilling mud components were based on data from the SimaPro life cycle tool and the EIO-LCA economic model (PRé Consultants 2007, CMU GDI 2010).

Hydraulic fracturing associated GHG emissions result from the operation of the diesel compressor used to move and compress the fracturing fluid to high pressure, the emissions associated with the production of the hydraulic fracturing fluid, and from fugitive methane emissions as flowback water is captured. The last category of emissions is discussed separately below. Energy and emissions associated with the hydraulic fracturing process were modeled by using vendor specific diesel data along with the emission factor described above. The emissions of hydraulic fracturing fluid production are estimated with EIO-LCA model, based on the price of additives and fracturing fluid composition (see supplementary information available at stacks.iop.org/ERL/6/034014/mmedia for detail).

There may be significant GHG emissions as a result of flaring and venting activities that occur during well casing and gathering equipment installation. The natural gas associated with the hydraulic fracturing flowback water is flared and vented. Flaring is used for testing the well gas flow prior to the construction of the gas gathering system which transport the gas to the sales line. Well completion emissions depend on the flaring/venting time, gas flow rate during well completion, the ratio of flaring to venting, and flaring efficiency. Uncertainty/variability analysis was conducted to investigate the effect of flaring/venting time, gas flow rate during fracturing water flowback, and flaring per cent on the well completion emissions. For those well completions with the collection facilities in place, gas is flared for between 12 and 24 h, due to necessary flowback operations. In wells where the appropriate gas gathering system as a tie to the gas sales line is not available for the gas during fracturing water flowback, the flaring or venting can occur for between 4 and 15 days as shown in table 2 (NY DEC 2009). In our model, we assumed the gas release rate during well completion equals the initial 30 day gas production rate for the base case and considered a scenario with both venting and flaring (see supplementary information available at stacks.iop.org/ERL/6/034014/mmedia for details).

3.2. Emissions from Marcellus shale gas production to combustion

GHG emissions for production, processing, transmission, distribution and combustion of Marcellus shale natural gas are assumed to be similar to the US average domestic gas system that have been estimated previously (Jaramillo *et al* 2007). Jaramillo *et al* (2007) estimates were updated to include the uncertainty and variability in life cycle estimates and recalculated with recent and/or more detailed information by Venkatesh *et al* (2011). The GHG emissions from these life cycle stages consist of vented methane (gas release during operation), fugitive methane (unintentional leaks) and CO_2 emissions from the processing plants and from fuel consumption. Methane leakage rates throughout the natural gas system (excluding the preproduction processes previously discussed) are a major concern and our analysis has an implied fugitive emissions rate of 2%, consistent with the EPA natural gas industry study (US EPA 1996, 2010).

Venkatesh *et al* (2011) estimated the mean emission factors used in this study: 9.7 g CO_2e/MJ of natural gas in production; 4.3 g CO_2e MJ for processing; 1.4 g CO_2e/MJ for transmission and storage; 0.8 g CO_2e/MJ for distribution; and 50 g CO_2e/MJ for combustion.

3.3. Emissions associated with the life cycle of water used for drilling and hydraulic fracturing

Water resource management is a critical component of the production of Marcellus shale natural gas. Chesapeake Energy (2010) indicates that 100 000 gallons of water are used for drilling mud preparation. Two to six million gallons of water per well are required for the hydraulic fracturing process (Staaf and Masur 2009). About 85% of the drilling mud is reused (URS Corporation 2010). The flowback and recycling rates are used to estimate the total volume of water required. About 60–65% of this hydrofracturing fluid is recovered (URS Corporation 2010). For the flowback water, a recycle rate from 30 to 60% can be achieved (Agbaji *et al* 2009). The rest of the flowback water is temporarily stored in the impoundment and transported off site for disposal. Base case assumptions for these parameters are shown in table 2.

Emissions associated with drilling water use and hydraulic fracturing water use result from water taken from surface water resources or a local public water system; truck transport to the well pad, and then from the pad to disposal via deep well injection. It is assumed that no GHG emissions are related

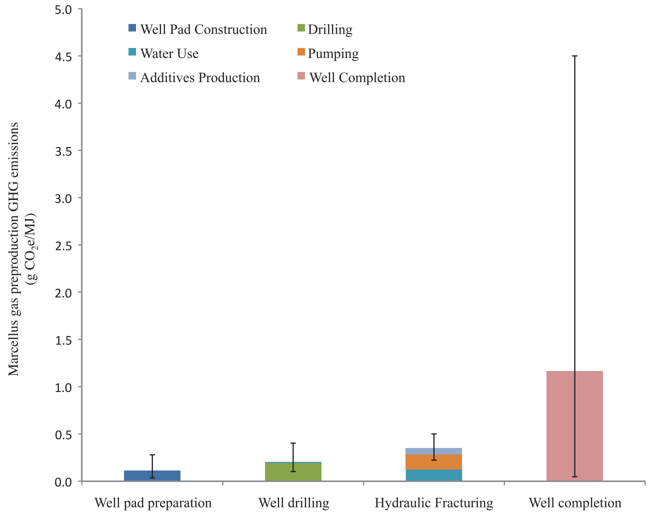

Figure 3. GHG emissions from different stages of Marcellus shale gas preproduction.

with producing water if it comes from surface water resources. For the water purchased from a local public water system, the emission factor for water treatment is used, which is estimated to be 3.4 g CO_2e/gallon of water generated according to Stokes and Horvath (2006). The energy intensity for transportation of liquids via truck is assumed to be 1028 Btu/ton mile for both forward and back-haul trips, as given in the GREET model (Wang and Santini 2009). In this study we assume that separate round trips are needed to transport the freshwater to the pad and to remove wastewater to the disposal site. This is to say that trucks bring in the freshwater from the source and return to the source empty; trucks also collect the wastewater from the well site and return to the well site empty. The life cycle emission factor (wells to wheels) for diesel as a transportation fuel is 93 g CO_2e/MJ (Wang and Santini 2009).

To estimate transport emissions associated with water taken from surface streams and water purchased from the local public water system, we used spatial analysis (ArcGIS) to estimate the distance from the surface water source to the well pad using well operational data and geographical information from Pennsylvania Department of Environmental Protection (2010). We depicted the overall distribution pattern of Marcellus wells under drilling and production in PA and NY in June 2010 by GIS. The distance from the well site to the surface water source is assumed to be 5 miles or 8 km in the base case of the model and the same transportation distance is also assumed for the water purchased from local public water system. We assumed an equal probability for sourcing water between surface water and the local public water system.

The trucking distance between well site and deep well injection facility was also estimated by GIS (PA DEP 2010). The average value of 80 miles or 130 km as determined by GIS was used in the base case.

4. Results for the base case

A total of 5500 t CO_2e is emitted during 'preproduction' per well. This is equivalent to 1.8 g CO_2e/MJ of natural gas produced over the lifetime of the well. Figure 3 depicts the GHG emissions by preproduction stage and by source. As can be seen, the completion stage has the largest GHG emissions, which result from flaring and/or venting. The error bars represent the limits of the 90% confidence interval of the emissions from each stage based on the uncertainty analysis.

A recent EPA report addressing emissions from the natural gas industry reported that 177 t of CH_4 is released during the completion of an unconventional gas well (US EPA 2010). This estimate is consistent with the analysis here and falls within the range estimated by our study, 26–1000 t of CH_4 released per completion and a mean value of 400 t of CH_4 released per completion. In our model, this methane released during the well completion is either flared with a combustion efficiency of 98% or vented without recovery.

Adding the preproduction emissions estimate to the downstream emission estimated by Venkatesh *et al* (2011) results in an overall GHG emissions factor of 68 g CO_2e/MJ of gas produced (figure 4). The life cycle emissions are dominated by combustion that accounts for 74% of the total emissions.

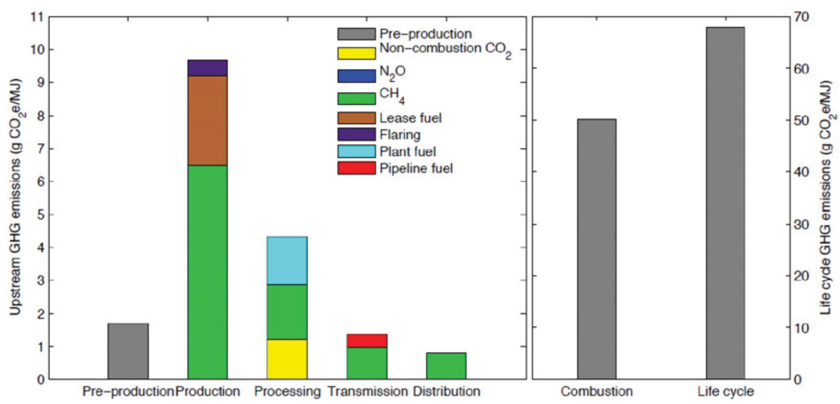

Figure 4. GHG emissions through the life cycle of Marcellus shale gas. (Preproduction through distribution emissions are on left scale; combustion and total life cycle emissions are on right scale. No carbon capture is included after combustion.)

Table 3. Uncertainty analysis on Marcellus gas preproduction.

Life cycle stage	Mean ($g\ CO_2e/MJ$)	Standard deviation ($g\ CO_2e/MJ$)	COV	90% CI-L (%)	90% CI-U (%)
Well pad preparation	0.13	0.1	0.72	58	131
Drilling	0.21	0.1	0.50	51	95
Hydraulic fracturing	0.35	0.1	0.24	37	42
Completion	1.15	1.8	1.53	96	287
Total	1.84	1.8	0.96	67	179

Table 4. Sensitivity of emissions from wells with different production rates and lifetimes. (Source: author calculations.)

Average gas flow (MMscf/day)	Lifetime (years)	Emissions from preproduction ($g\ CO_2e/MJ$)	Preproduction % contribution to life cycle emissions of Marcellus shale gas (%)	Total life cycle emissions ($g\ CO_2e/MJ$)
10	25	0.1	0.1	65.3
10	10	0.1	0.2	65.3
10	5	0.3	0.4	65.5
3	25	0.2	0.3	65.4
3	10	0.5	0.7	65.7
3	5	0.9	1.4	66.1
1	25	0.6	0.8	65.8
1	10	1.4	2.1	66.6
1	5	2.8	4.1	68.0
0.3	25	1.8	2.7	67.0
0.3	10	5	6.6	69.8
0.3	5	9.2	12.4	74.4

5. Sensitivity and uncertainty

Our results are subject to considerable uncertainty, particularly for the production rates and well lifetime. Table 3 summarizes the uncertainty analysis on the emission estimates for preproduction based on the distribution of parameters used.

Table 4 addresses model sensitivity to different estimates of ultimate gas recovery from wells, investigating the impact of different production rates and lifetimes. At high production rates and long well lifetimes the preproduction GHG emissions are normalized over higher volumes of natural gas than when using low flow rates and short well lifetimes. Comparing the case of 10 MMscf/day with a 25-year well lifetime to 0.3 MMscf/day with a 5-year well lifetime, table 4 shows that the emissions go from 0.1 to 9.2 g CO_2e/MJ. The overall life cycle emissions change from 65 to 74 g CO_2e/MJ. However, the preproduction emissions are less than 15% of the total life cycle emissions in all cases.

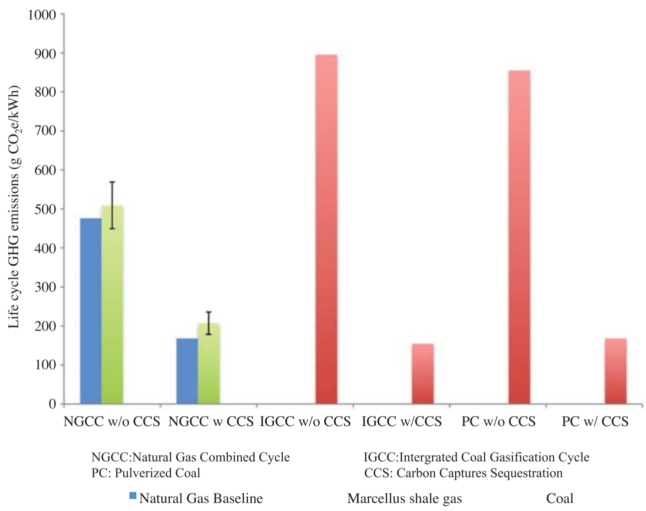

Figure 5. Comparison of life cycle GHG emissions from current domestic natural gas, Marcellus shale gas and coal for use in electricity production.

6. Comparison with coal for power generation

Marcellus shale gas emissions can be compared to alternative energy sources and processes when using a common metric such as electricity generated. Currently coal power plants are used to generate base load. Natural gas power plants, especially inefficient ones, are used to provide regulation services to balance supply and demand at times when base load power plants are insufficient or there is high-frequency variability in load or from renewable resources. Natural gas combined cycle (NGCC) plants could be used to generate base load thus competing directly with coal to provide this service. For this reason our comparison includes the emissions associated with using Marcellus shale gas in a NGCC power plant (efficiency of 50%) and the emissions from using coal in pulverized coal (PC) plants (efficiency of 39%) and integrated gasification combined cycle (IGCC) plants (efficiency of 38%). The results of these comparisons can be seen in figure 5. For this comparison point values are used for the life cycle GHG emissions of coal-based electricity. The error bars found in figure 5 represent the low and high emissions values for Marcellus shale gas, based on the assumptions of well production rate and well lifetime. The high-emission scenario assumes a 5-year well with 0.3 MMscf/day production rate while the low-emission scenario, assumes a 25-year well with 10 MMscf/day production rate. Also shown in figure 5 are the life cycle emissions of electricity generated in power plants with carbon capture and sequestration (CCS) capabilities (efficiency of 43% for NGCC with CCS; efficiency of 30% for PC with CCS; efficiency of 33% for ICGG with CCS).

In general, natural gas provides lower greenhouse emission for all cases studied whether the gas is derived from Marcellus shale or the average 2008 domestic natural gas system. When advanced technologies are used with CSS then the emissions are similar and coal provides slightly less emissions. This implies that the upstream emissions for natural gas life cycle are higher than the upstream emissions from coal, once efficiencies of power generation are taken into account (Jaramillo *et al* 2007).

The comparison of natural gas and coal for electricity allows us to investigate the impact of three additional model uncertainty components including the choice of leakage rate, GWP values, and re-refracking of a Marcellus gas well. This study assumes a 2% production phase leakage rate based on the volume of gas produced (US EPA 2010, Venkatesh *et al* 2011). Assuming the average efficiency of 43% for natural gas fired electricity generation and 32% for coal fired plants the fugitive emissions rate would need to be 14% (resulting in a life cycle emission factor for Marcellus gas of 125 g CO_2e/MJ) before the overall life cycle emissions including those of electricity generation would be greater than coal. This is an exorbitantly high leakage rate and to put it into perspective, using 2009 dry natural gas production estimates and the average wellhead price, we calculate that the economic losses a would total around $11 billion. If we convert our data to the 20-year GWP the break-even point is reduced to 7% because of the higher impacts attributed to methane. Finally, we modeled a single hydraulic fracturing event occurring during well preproduction (figure 3). Above we calculated that the break-even emission factor that would make coal and natural electricity generation the same is 125 g CO_2e/MJ of natural gas. With the current emissions estimate for Marcellus gas of 68 g CO_2e/MJ, and a hydraulic fracturing event (and its associated flaring and venting emissions) contributing 1.5 g CO_2e/MJ to this estimate, more than 25 fracturing events would need to occur in a single well before the decision between coal and natural gas would change.

7. Comparison with liquefied natural gas as a future source

In 2005 EIA suggested that domestic natural gas production and Canadian imports would decline as natural gas consumption increased. EIA predicted that liquefied natural gas (LNG) imports would grow to offset the deficits in North American production (US EIA 2011a, 2011b). As a result of the development of unconventional natural gas reserves, EIA has changed their projections. The Annual Energy Outlook 2011 reference case (US EIA 2011a, 2011b) predicts that increases in shale gas production, including Marcellus, will more than offset the decline in conventional natural gas and decreasing imports from Canada and will allow for increases in natural gas consumption. Since shale gas is projected to be the largest component of the unconventional sources of future natural gas production, it seem appropriate to compare its emissions to those of the gas that would be used if shale gas were not produced. Venkatesh *et al* (2011) estimated the life cycle GHG from LNG imported to the US to have a mean of 70 g CO_2e/MJ, These results are based on emissions due to production and liquefaction in the countries of origin, shipping the gas to the US by ocean tanker, regasification in the US and its transmission, distribution and subsequent combustion. On average, the emissions of Marcellus shale gas were about 3% lower than LNG. As with the overall Marcellus gas results, there is considerable uncertainty to the comparisons. However, we conclude that as these unconventional sources of natural gas supplant LNG imports, overall emissions will not rise.

8. Conclusion

The GHG emission estimates shown here for Marcellus gas are similar to current domestic gas. Other shale gas plays could generate different results considering regional environmental variability and reservoir heterogeneity. Green completion and capturing the gas for market that would otherwise be flared or vented, could reduce the emissions associated with completion and thus would significantly reduce the largest source of emissions specific to Marcellus gas preproduction. These preproduction emissions, however, are not substantial contributors to the life cycle estimates, which are dominated by the combustion emissions of the gas. For comparison purposes, Marcellus shale gas adds only 3% more emissions to the average conventional gas, which is likely within the uncertainty bounds of the study. Marcellus shale gas has lower GHG emissions relative to coal when used to generate electricity.

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Global food security: *facts, issues and implications*

Brian Moir and Paul Morris

- The challenge of food security is to ensure that all people have physical and economic access to food that meets their dietary needs and food preferences for an active and healthy lifestyle.
- Growth in global food consumption is expected to slow significantly over the next 40 years, from an average rate of 2.2 per cent a year (1970 to 2000) to 1.3 per cent a year (2000 to 2030) and then to 0.6 per cent a year (2030 to 2050).
- Nevertheless, the population of some food-deficient countries will continue to grow while others decline.
- Improving agricultural productivity globally, and particularly in food-deficient countries, will be important to meet this challenge, as will continued improvements in international trading rules that allow the flow of food to where it is needed.
- Food security also requires economic development and higher incomes in the least developed countries, which will reduce poverty and increase the access of the poor to food.
- There are many future challenges to increasing food production globally, including slowing agricultural productivity growth, the impacts of climate change, and increased competition for scarce resources such as water, fertiliser and land.
- Australia produces far more food than it consumes and has the income to meet all its food security needs. However, its surplus food production meets only a small part of world food consumption needs. Australia's greatest contribution to global food security will be through provision of technical cooperation assistance to food-deficient countries.

Global food requirements will continue to increase in coming years, as populations rise and as growing incomes promote both an increasing volume and a changing pattern of food consumption. This paper examines issues around global food security from an Australian perspective.

Food security has two dimensions: the physical availability of food, and the capacity of people to pay for the food they need. Food security does not imply self-sufficiency. The Food and Agriculture Organization (FAO) has estimated that 925 million people do not have sufficient food to eat. The continuing existence of this large population of undernourished people is a problem of poverty demanding long-term solutions that are targeted to the needs of individual countries.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 2003).

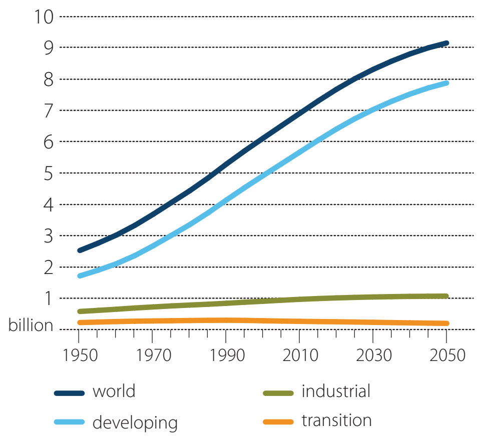
There is no foreseeable risk to Australia's food security. Australia produces twice as much food as it consumes, produces almost all its fresh food, and can easily afford the food it imports. Australia is also a competitive supplier of bulk commodities, fresh foods and processed foods (such as meat and dairy products) to world markets. However, Australia's strength in providing food to other countries faces a number of challenges over coming decades. The rate of growth in agricultural productivity is declining in Australia, and perhaps globally, as growth in investment in research and development (R&D) has declined. Additional challenges include climate change, increasing pressure on limited resources such as land, water and fertiliser, and, if Australia follows the path of a number of other countries, demand from non-food uses of crops, particularly for biofuel.

Global population growth

United Nations population data and projections (UN 2009) show the global population reaching 9.1 billion by 2050, an increase of 32 per cent from 2010. Most of the additional population will be in developing countries. Between countries and regions, population trends show considerable diversity. The Americas, Africa and Oceania are projected to show continuing population growth through this period. However, the population of the Russian Federation has been declining for the past 15 years, Europe's population is expected to peak in the course of the current decade, and China's in the 2030s. By 2050, global population growth is projected to slow to 0.34 per cent annually (compared with an annual average of over 2 per cent in the late 1960s, and a little over 1 per cent currently) and is likely to begin contracting later in the century. However, significant population growth is likely to continue beyond this time in some of the world's most food insecure regions (Lutz, Sanderson and Scherboy 2001).

The word's population growth is slowing, but the populations of some food-deficient countries will continue to grow while others decline. Food security is an issue that needs to be considered in a regional context.

1 Growth of world population



Note: For a list of countries in each of these categories, see FAO (2006). In short, industrial countries are those of Western Europe and North America plus Australia, New Zealand, Japan, South Africa and Israel. Developing countries include the bulk of those in Asia, including the Middle East, Africa, Latin America and Oceania. Transition countries include the Russian Federation and others of the former USSR and Eastern Europe, including those that have joined the European Union
Source: UN 2009

In absolute terms, the world's population is expected to grow by 2.2 billion in the next 40 years to 2050, and a significant part of the additional population will be in countries that have difficulties feeding themselves.

Almost one billion (or 43 per cent) of the additional population will be in Africa. Countries such as Niger, Ethiopia and Uganda are among those likely to face high population growth and ongoing food security problems (FAO 2006). Asia's population will increase by more than one billion, including 400 million additional people in India. China's small and subsequently negative rate of growth will nevertheless represent an additional 63 million people by 2050.

Global income growth

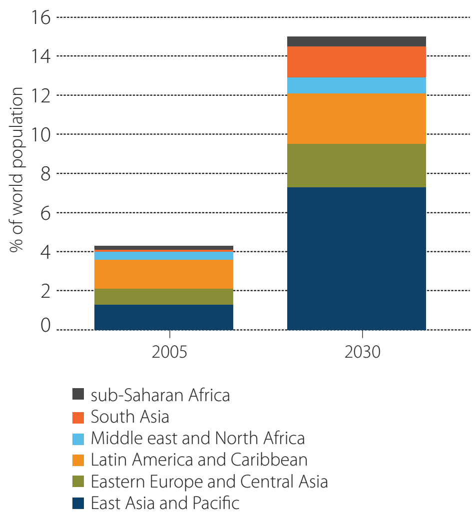
The World Bank (2007) has forecast that the developing countries will increasingly power the global economy, with their per capita incomes growing by 3.1 per cent a year, on average, between 2010 and 2030. The share of the developing countries in global output is expected to increase from about one-fifth to nearly one-third, and they may represent half of the world's purchasing power by 2030. China and India will be major drivers of this economic growth and of an associated expansion in global trade. But this growth is not likely to be uniform across developing countries, with sub-Saharan Africa experiencing much slower growth than other regions. Per capita incomes in the developing countries of East Asia and the Pacific are forecast to grow by between 4.5 and 6.5 per cent annually, and in South Asia by between 2.5 and 5 per cent annually. The benefits would also not be spread evenly within countries. Technological progress demands skilled workers, and the unskilled may fall further behind.

Continuing economic growth and an expansion in the middle classes, particularly in Asian countries, will also drive increased food consumption.

Growth in demand for food and changing patterns of demand

The effect of growing incomes will be more visible where base levels of consumption are lower; that is, as a population moves from poverty towards middle class. As shown in figure 2, the proportion of the world population accounted for by middle classes in developing countries is expected to expand from around 4.9 per cent in 2005 to almost 15 per cent in 2030. At higher income levels, people already have a more adequate diet and there is less potential for food consumption to increase further. FAO projections show global food consumption per person (expressed as kcal/person/day) increasing by an average 0.29 per cent a year in the period to 2030, but growing more slowly at 0.15 per cent a year in the period 2030 to 2050 (FAO 2006). However, growth rates will be around double this in food deficient regions of the world such as sub-Saharan Africa and South Asia.

2 Middle class, incomes of $4000 to $17 000 (PPP)



PPP Purchasing Power Parity facilitates comparison between countries with different price levels
Source: World Bank Global Economic Prospects 2007

Combining expected population growth with income growth means food consumption will increase by 68 per cent between 2000 and 2050. This implies an annual growth rate of 1.04 per cent, compared with growth of 2.2 per cent annually between 1970 and 2000.

1 Projected growth in population and food consumption

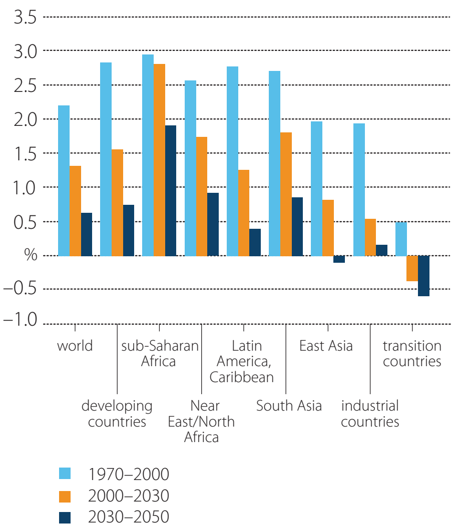
	average annual growth rates, %, 1970–2000			average annual growth rates, %, 2000–2030			average annual growth rates, %, 2030–2050		
	kcal/ person [a]	population [b]	food consumption	kcal/ person [a]	population [b]	food consumption	kcal/ person [a]	population [b]	food consumption
World	0.49	1.70	2.20	0.29	1.03	1.32	0.15	0.48	0.63
Developing countries	0.77	2.05	2.83	0.36	1.20	1.56	0.18	0.57	0.75
Sub–Saharan Africa [c]	0.15	2.80	2.95	0.57	2.23	2.81	0.42	1.48	1.91
Near East / North Africa [c]	0.00	2.57	2.57	0.17	1.56	1.74	0.09	0.82	0.92
Latin America and Caribbean	0.74	2.02	2.77	0.32	0.94	1.26	0.13	0.28	0.40
South Asia	0.47	2.23	2.71	0.51	1.29	1.81	0.33	0.53	0.86
East Asia [c]	0.49	1.48	1.97	0.35	0.47	0.82	0.06	–0.17	–0.10
Industrial countries	1.19	0.74	1.94	0.07	0.47	0.54	0.03	0.13	0.16
Transition countries	0.41	0.08	0.49	0.28	–0.64	–0.37	0.19	–0.78	–0.59

a Calculated from FAO (2006) table 2.1, p. 8. **b** From UN population data, v. **c** FAO Developing regions. Japan, Israel and South Africa not included.
Kcal=1000 calories, a measure of the energy contained in food.

The average calorie intake for developing countries is expected to rise from 2650 kcal a person a day in the mid-2000s to 3000 kcal a person a day by 2050, thus significantly improving nutrition. However, it is likely that considerable population groups will remain deficient in food.

> *With global food consumption growing at decreasing rates to 2050, agricultural production can also expand at a slower rate than in the past without prices rising.*

3 Annual rate of growth in food requirements



Source: Extrapolated from FAO (2006) and UN population data, http://esa.un.org/unpp/index.asp

A different pattern of food consumption is emerging, as higher demand for livestock products is stimulated by increasing disposable incomes in developing countries, especially in the emerging markets of Asia, Latin America and the transition countries of Eastern Europe and the former USSR. Consumption of livestock products (meat, milk and eggs), vegetable oils and, to a lesser extent, sugar, forms an increasing proportion of intake as incomes and food consumption grow. In Asia, demand growth for meat and edible oils outstripped population growth by a wide margin over the past 15 years (World Bank 2009). Demand for meat and dairy products (and feed grains) is expected to continue to expand more rapidly than demand for grain.

Food consumption patterns vary markedly between the developing regions. Sub-Saharan Africa and South Asia have particularly low levels of meat consumption. There are a number of developing countries where meat consumption is less than 10 kg a person a year, and in some of these the trend is downward. (By comparison, Australian meat consumption in recent years has varied between 100 and 110 kg a person). In the case of South Asia, annual meat consumption is estimated at 5.5 kg a person in 2000, projected by the FAO to increase to 18 kg a person through the first half of the 21st century. East Asia, in contrast, consumes much more meat—39.8 kg a person in 2000—and this is expected to increase to 73 kg a person by 2050. Consumption per person of vegetable oils is expected to increase by 60 per cent in developing countries through the first half of the century; in South Asia, this consumption will almost double (FAO 2006). Consumption of fresh fruit and vegetables is projected to expand in some countries, including China and some in the Middle East and North Africa, but less in others (Msangi and Rosegrant 2011).

Global food production

Global food production has historically grown faster than global population, reflecting increased availability of food per person. Between 1961 and 2008, world population grew by 117 per cent while food production grew by 179 per cent (Keating and Carberry 2010). Declining real prices over a long period indicate that, with growth in productivity, supply has strengthened more rapidly than demand. Food production would be higher if there was stronger demand for food. However, this under-utilised production capacity coexists with almost one billion undernourished people unable to afford sufficient food at their income levels and current food prices.

With populations and incomes growing, agricultural production will need to continue to increase, albeit at a slower rate, if future demand for food is to continue to be met at current price levels. Strong productivity growth and the utilisation of hitherto unused cropping should ensure the continuing adequacy of food supplies (World Bank 2009).

Improvements in agricultural productivity over time have enabled agricultural production to meet consumption growth while lowering the real price of food. The challenges to continuing these productivity increases remain high in the future.

The increased emphasis on consumption of livestock products will influence production patterns in the future. According to the FAO, global production of meat has expanded by around 2.2 per cent annually for the past decade and is expected to continue growing, but at a slower rate, to 2050. The FAO projects that growth in wheat production, which has been around 1.4 per cent a year in the past decade, will slow to 0.5 per cent a year by the middle of the century. Coarse grains output, fuelled by growing demand for livestock feed and for industrial uses such as ethanol production, has grown by 2.3 per cent annually in the past decade, and is expected to grow significantly faster than wheat over the next 40 years.

While past growth in agricultural production, sustained in large part by technologically driven gains in yields, may be taken as a guide to future potential, there are challenges to future productivity growth. Per capita availability of resources such as water and land will become more limited, while climate change may require adjustments to production techniques and locations. Potential increases in the cost of mineral fertilisers and in the use of resources to produce crops for non-food uses, particularly for biofuel, may both drive up the cost of producing food.

The supply of food could be further enhanced if waste were to be reduced. Keating and Carberry (2010) note that estimates of post-harvest losses range from 10 to 40 per cent. Even at the bottom of this range the food supply could be increased markedly by reducing losses.

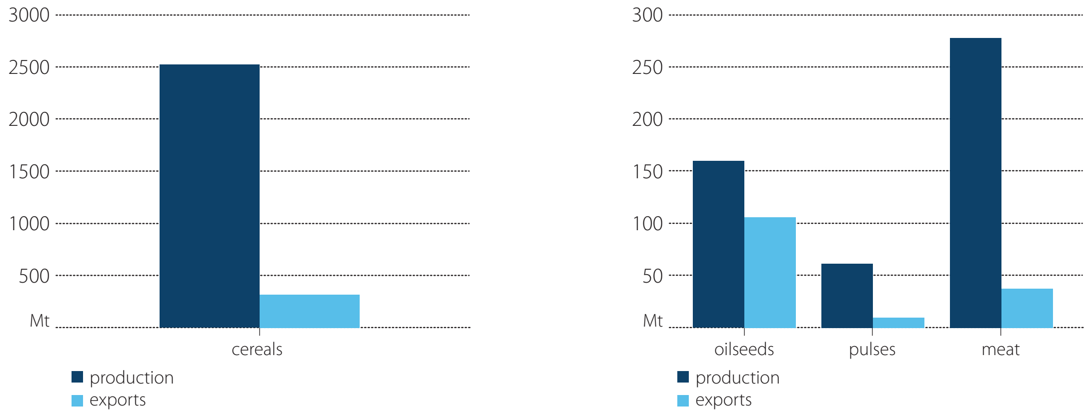
Research and development on food supply chains could be as important to food security as research to improve yields.

Global trade in food

While global trade in foodstuffs is of considerable importance—to some countries more than others—it constitutes a relatively small proportion of total world production and consumption. Exports of meat, cereals and pulses over the period 2000 to 2007 averaged 11, 13 and 16 per cent of global production, respectively; however, trade in oilseeds was much more significant, at 62 per cent of production. Exports of meat and pulses, relative to their levels of production, have increased over the past 20 years (FAO 2010a).

The removal of import and export barriers will be an important part of meeting the global challenge of moving food to where it is most needed and, through improved incomes, enhancing people's capacity to buy food.

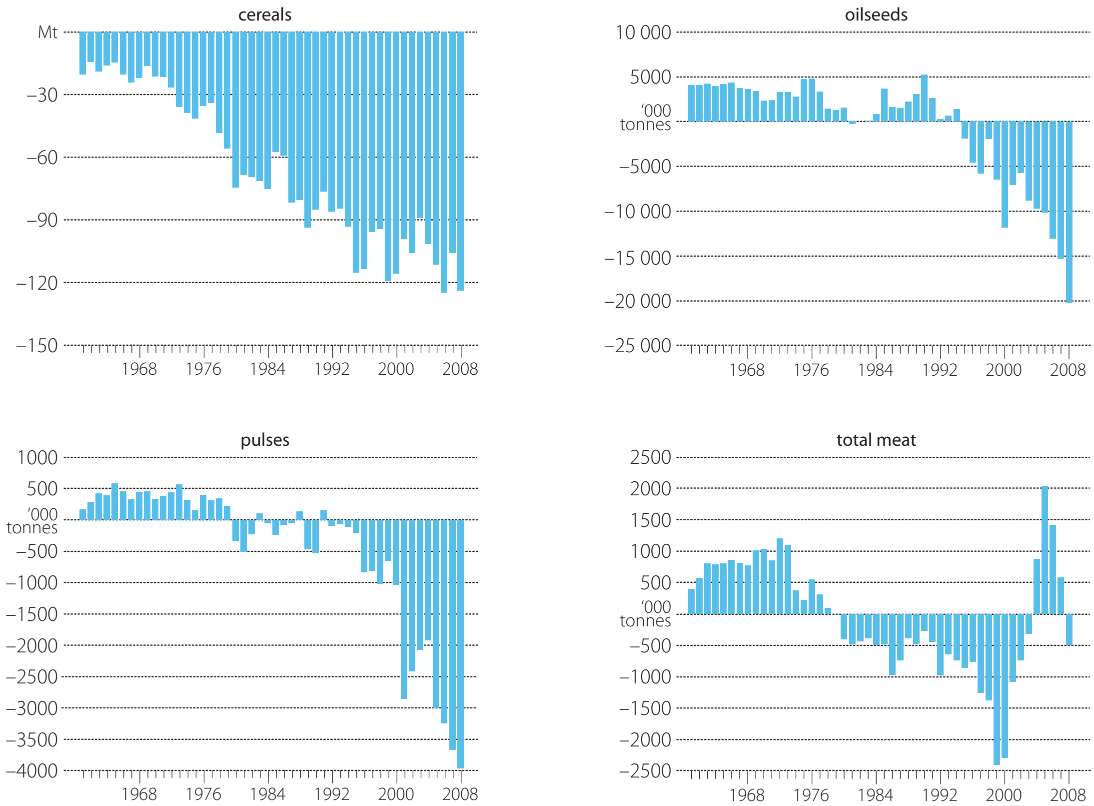
4 Global production and exports of selected commodities



Source: FAO 2010a

Overall, developed countries have tended to dominate food exports in recent decades, in many cases with the assistance of their agricultural support programs, while developing countries in the aggregate have been net importers. World trade in foodstuffs is dominated by cereals, particularly wheat. The United States, Canada, the Russian Federation, the European Union and Australia are the major net exporters of wheat, shipping to countries in Africa, Asia, Latin America and the Middle East (the trade flowing predominantly from developed and transition countries to developing countries). Trade in other commodities shows a less consistent pattern between developing and developed countries over time. Since the mid-1990s the developed countries have come to dominate exports of oilseeds and pulses. However, developing countries dominated meat exports from 2004 to 2007, as Brazil's shipments of beef expanded markedly and those of the United States were variable.

5 Net exports from developing countries



Source: FAO 2010a

The policy framework in which global trade takes place will be important for future food security. Import restrictions clearly limit trade, and while tariffs on food commodities are typically fairly low, other barriers are often applied.

6 FAO food price index, 2002–2004 = 100 deflated by World Bank MUV deflator

Source: www.fao.org
MUV Manufactures Unit Value deflator

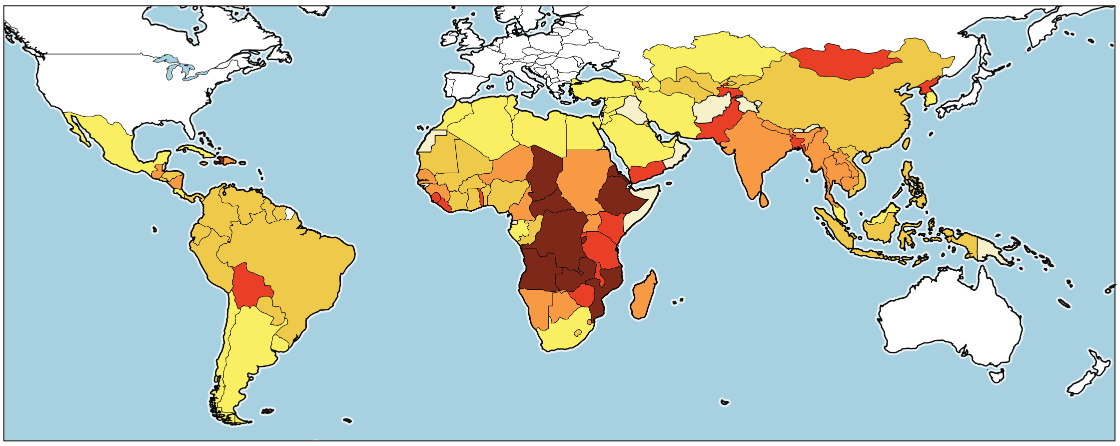
In situations of high global food prices in recent years, some countries have imposed restrictions on exports. This immediately increases the availability of food and reduces its price to consumers in the country concerned, while having the opposite effect on the global food market. Importantly, it also disguises incentives to farmers in that country to increase production at a time when more food is most needed globally.

Similarly, export subsidies and food aid provided in non-emergency situations can have the effect of lowering incentives to produce food for farmers in recipient countries. Such arrangements are conducive to continued poverty over the long run rather than creating an environment for poverty alleviation.

Trade liberalisation, including reform of agricultural support regimes, improves the allocation of resources to different activities in the economy and thus increases incomes. Higher incomes reduce poverty and improve food security by increasing the access of the poor to food.

For some countries, food imports are, and will remain, crucially important to their food security. The low-income food-deficit countries rely on imports, for which many struggle to pay, and are the focus of attention on the world's hungry. For these people it is not the physical availability of food but their ability to pay for it that is critical to survival. The United Nations Millennium Declaration of 2000 set out eight major Millennium Development Goals, the first of which is to eradicate extreme poverty and hunger (United Nations 2010). Two of the targets specified under this goal are to halve, between 1990 and 2015, the proportion of people whose income is less than US$1 a day, and to halve, between 1990 and 2015, the proportion of

map **1** Prevalence of undernourishment in total population (%), 2005–07



very high (undernourishment 35% and above)
high (undernourishment 25-34%)
moderately high (undernourishment 15-24%)
moderately low (undernourishment 5-14%)
very low (undernourishment below 5%)
missing or insufficient data

Source: FAOSTAT 2010 (www.fao.org/hunger) people who suffer from hunger. Through the period of high food prices in 2007–08 and the subsequent global financial crisis the number of hungry people grew from 847 million to more than one billion. In 2010 the FAO estimated that the number had fallen to 925 million (FAO 2010c), due largely to a more favourable economic environment in 2010 and the fall in food prices in 2009. Subsequently, however, food prices rose in 2010 and into 2011 to exceed the high levels of 2008, and the number of undernourished people may be expected to have risen again. Map 1 shows the global distribution of undernourished people.

Assisting developing countries achieve food security

Developing countries require assistance to improve both the ability of their people to buy food—through economic development—and their ability to produce food. As a middle-sized developed economy, Australia seeks to maximise the effectiveness of the aid it provides to these countries and needs to ensure this is targeted towards encouraging economic development.

Poor, food-deficit countries face many problems. Undernourishment itself deepens other aspects of poverty by reducing capacity to work, reducing resistance to disease and inhibiting children's mental development and educational achievements (FAO 2002). Such countries typically suffer from poor infrastructure, low levels of education and skills, limited investment, and low levels of inputs used in agriculture. The labour forces of many African countries in particular have been devastated by HIV/AIDS. In many countries, poor governance at all levels is a barrier to stable agricultural production and growth.

Increased agricultural production generates income, leads to reduced poverty and improved food security in rural areas, and can become an engine for broader economic development and hence for improved national food security. As a country with advanced expertise in agricultural technology, economics and policy, supported by strong educational and research institutions, Australia is well placed to help global food security by providing technical assistance to developing countries to improve their own agricultural capacity.

The Australian Agency for International Development (AusAID) manages most of Australia's aid program. It provides development assistance and disaster relief to overcome poverty and facilitate food security on a bilateral basis in many developing countries, as well as working with multilateral agencies. It is currently implementing a four-year global food security initiative aimed at countries in Asia, the Pacific and Africa, which focuses on 1) lifting agricultural productivity; 2) improving access to and returns from markets; and 3) providing social safety nets to protect the vulnerable against economic and natural shocks.

The Australian Centre for International Agricultural Research (ACIAR) channels Australia's assistance directly to the development of agriculture in thirty countries in five regions: Papua New Guinea and the Pacific; Southeast Asia; North Asia; South Asia; and Africa. It is a statutory authority that encourages Australia's agricultural scientists to use their skills for the benefit of developing countries. It commissions research into improving sustainable agricultural production in developing countries, funds related training and communicates the results of funded research. Australia contributes to a wide range of agricultural research in developing countries through its support of the Consultative Group on International Agricultural Research and its network of International Agricultural Research Centres.

In addition, Australia contributes to alleviation of poverty and hunger by supporting the United Nations and its specialised agencies such as the FAO and the World Food Programme, as well as the World Bank. The G20 group of countries is also becoming increasingly significant in anti-poverty and food security activities.

Australia is a member of the World Trade Organization and participates actively in discussions and negotiations to help encourage a more open global trading system, which is an important contributor to global food security.

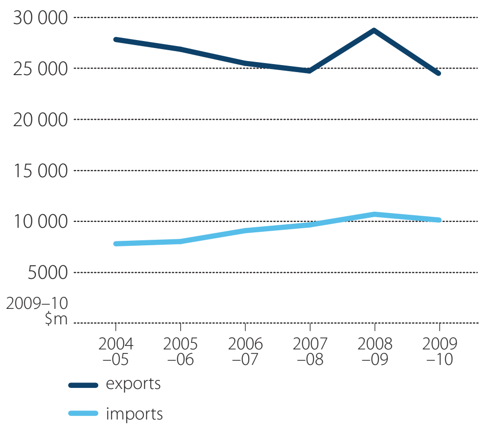
Australia's food security

As a trading nation with an open economy, growth in Australia's food production is likely to focus primarily on those products for which it has comparative advantage; that is, on those products in which Australia can compete internationally. For example, Australia has traditionally had a comparative advantage in broadacre agricultural products that are produced with the extensive use of land and limited inputs of labour. These commodities include cereals, oilseeds, beef and sheep meat, as well as sugar and dairy. These products are likely to continue to form a major part of Australia's food exports.

While food imports by Australia have been increasing in the past decade, Australia remains in a strong surplus position. Australia's integration in the global food economy with an increasingly sophisticated pattern of exports, imports, processing and distribution provides the Australian consumer with choice among a greater diversity of products, with more price competition. Economic prosperity, derived in part from participation in the global economy, guarantees Australia's food security.

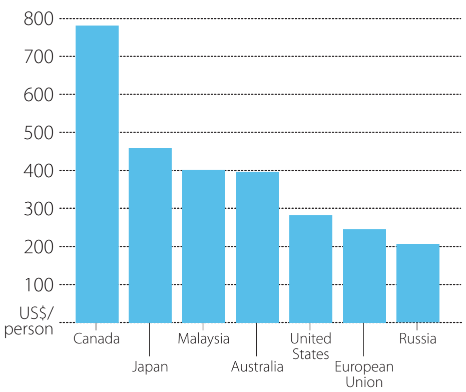
Most of Australia's tariff and quota measures against agricultural imports have been removed during the past two decades. In addition, quarantine measures have been established that allow the import of a greater number of products while managing the risk of entry of pests and diseases. This has resulted in notable increases in imports of, for example, pig meat and some horticultural products. Because of the perishability of fruits and vegetables and the availability of low-cost domestic produce, imports of horticultural products are dominated by processed product, which accounts for around 90 per cent of fruit and vegetable imports. Where fresh fruit and vegetables are imported, these are often counter-seasonal to Australia's production.

8 Food exports and imports



Sources: ABARES 2011 *Australian commodities* March quarter

7 Food imports per person in selected countries, 2009–2010



Sources: Comtrade, United Nations Commodity Trade Statistics Database, http://comtrade.un.org/db/dqBasicQuery.aspx; United Nations 2009, World population prospects, the 2008 revision, population database, Population: http://esa.un.org/unpp/

Although imports are playing a larger role in Australia's food supply, Australia's agricultural production is, overall, well in excess of consumption requirements, and a considerable surplus is available for export. Over the past decade, wheat production has averaged around 3.5 times the volume needed for domestic consumption, while beef and veal production has been around 2.8 times the quantity consumed (derived from ABARES 2010). Total food exports averaged over the three years 2006–07 to 2008–09 amounted to 54 per cent of food production (Penm, Rees and Moir 2010). Expenditure on imports in 2009–10 amounted to more than 40 per cent of the receipts for food exports, but most of Australia's imported food is relatively highly valued, with a high level of processing, and the quantity of food involved is much less than suggested by its cost.

The high income levels of most Australians ensures their capacity to purchase the food they need, whether imported or domestically produced. As a consequence, Australia's food security would not be threatened by any diminution of food self sufficiency that might occur with increased imports in the future.

Australia's role in meeting global food needs

On average, between 2007–08 and 2009–10, Australia's exports of wheat and flour amounted to around 11 per cent of total world exports, but only 2 per cent of global consumption. Over the same period, Australia's sugar exports were equivalent to almost 6 per cent of global trade but only 2 per cent of consumption (ABARES 2010). Beef exports between 2004 and 2007 accounted for 15 per cent of global trade but only 1.5 per cent of global consumption (FAO 2010a).

Australia's exports contribute to the supply of food available to food-deficit counties. However, Australia is a relatively small producer in global terms, and exports are likely to be directed to markets of the highest value rather than to countries with the greatest food need.

The value of Australia's food exports in 2009–10 was $24.5 billion (ABARES 2011). Asian markets have become increasingly important destinations for Australian exports in the past two decades. Japan remains the most important destination, taking around 20 per cent of Australia's food exports by value. Indonesia, the Republic of Korea, Malaysia and China all now take a higher proportion of food exports than in 1990–91. New Zealand, the United Kingdom and some countries in the Middle East, including Saudi Arabia and the United Arab Emirates, have also become more important export destinations. Some of the countries to which Australia exports food have serious food security problems. In recent years, between 28 and 42 per cent of wheat shipments have been to countries where more than 10 per cent of the population is undernourished.

However, Australian exporters are focused on markets of highest value such as those of the developed economies and the rising middle classes in the growing developing countries, including China and the ASEAN countries, which are expected to shift in demand away from staples toward a wider variety of food products (Kim, Thompson and Penm 2010). To a large extent, Australia's food exports are not oriented towards countries with serious food security problems but rather the incentive is for farmers and exporters to supply the markets where they receive the highest returns for their products.

Australia has the capacity to feed far more people internationally through technical assistance in the agricultural sectors of the world's food-deficit countries than through the export of food produced in Australia.

Potential challenges to agricultural production

Productivity in agriculture

Productivity refers to production per unit of input. In agriculture, productivity is often expressed as yield, or production per unit of land used. This is a partial productivity measure in that production is related to a single input. Productivity with respect to other inputs, including labour, capital or water can also be considered. Total factor productivity is a measure that captures the change in production from a given set of all inputs.

Australian agricultural industries face a number of challenges to increased production in the future. These include the need for technological development that allows the continuation of advances in productivity; the influence of climate change; and competition for resources.

Around two-thirds of the gross value of agricultural production in Australia in recent years can be attributed to gains in productivity (Gray et al. 2011). Total factor productivity in Australian broadacre agriculture grew at an average of 1.4 per cent annually

2 Volume of Australian exports of wheat and flour to selected countries with food-deficit population a

	Wheat exports b					Food security characteristics of country c		
						Number undernourished (million)	Prevalence of undernourished in population	Depth of hunger – food deficit of undernourished population d
	2004–05	2005–06	2006–07	2007–08	2008–09	2005–2007	2005–07	2004–06
	kt	kt	kt	kt	kt	Million	%	kcal/ person/day
Ethiopia	0	8	0	0	5	32	41	310
Bangladesh	162	179	3	65	337	42	27	290
India	0	93	1 593	9	1	238	21	260
Indonesia	2 720	3 016	2 574	1 608	2 728	30	13	230
Pakistan	653	146	0	0	0	43	26	280
Sri Lanka	66	46	0	5	50	4	19	250
Thailand	478	545	192	255	336	11	16	210
Yemen	314	499	385	408	714	7	31	270
Sum of above	4 394	4 532	4 747	2 350	4 172	406		
Total to all destinations	15 780	15 168	11 196	7 408	13 410			
% to food insecure countries	27.8	29.9	42.4	31.7	31.1			

a Countries where more than 10 per cent of the population are undernourished. **b** July–June year. Exports are of wheat (including spelt, groats, meal and pellets) and meslin (mixed grain, especially rye mixed with wheat), plus plain white flour, wholemeal flour and self-raising white flour in wheat equivalent (conversion 1:1.29). Source: ABS, *International Trade, Australia*, cat. no. 5465.0, Canberra. **c** Source FAO 2010, Food security statistics, http://www.fao.org/economic/ess/food-security-statistics/en/. **d** The intensity of food deficit is considered low when it is less than 200 kilocalories a person a day and high when it is higher than 300 kilocalories a person a day.

between 1977–78 and 2007–08. In the period 1977–78 to 2000–01, productivity grew at 2 per cent a year in trend terms, but has since reversed to contract at 1 per cent a year in trend terms. Productivity growth in the dairy industry has similarly proceeded more slowly after 2000–01 (Nossal and Sheng 2010). While the reductions in productivity growth in recent years are due, at least in part, to adverse seasonal conditions and reduced irrigation water availability, they also indicate a fundamental slowdown in technological progress (Gray et al. 2011).

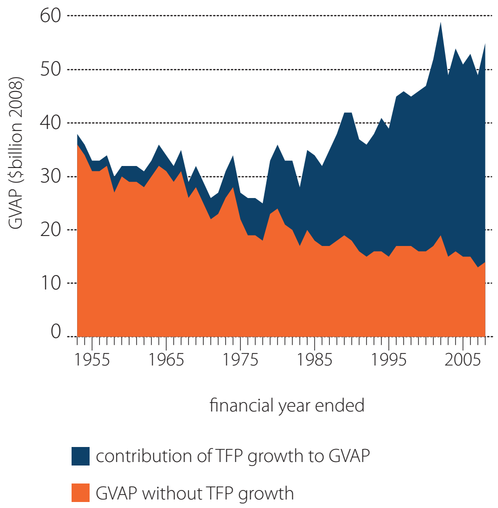
Globally, yields of major crops have increased more slowly in recent years than 30 and 40 years ago (Sheales and Gunning-Trant 2009).

A key driver of productivity growth is investment in R&D, and it is notable that Australian public expenditure on R&D in agriculture, which grew at an average of 6.5 per cent a year between 1953 and 1980, has since grown at only 0.6 per cent a year (Nossal and Sheng 2010). The effect of this slowdown in R&D may now be evident in the slower productivity growth. The negative effects of any reduced R&D effort may continue for a long time, as it may take up to 35 years for the full effects to be felt (Nossal and Sheng 2010). Private investment in agricultural research is also important, although data are less readily available. In the United States, private R&D expenditure in agriculture was reported to be growing faster than public expenditure, which it had exceeded by 1996 (Tokgöz 2002). In Australia, private R&D expenditure is much less than public spending. However, Australia does derive significant benefits from R&D undertaken by other countries, with this estimated to account for around half of the productivity gains in Australian agriculture between 1953 and 2007 (Sheng, Gray and Mullen 2011).

One notable outcome of research in recent decades is the development of genetically modified organisms (GMOs), including crop plants that are resistant to pests and that are able to withstand the herbicides used to control weeds. These plants have contributed to productivity gains in agriculture in recent years, particularly in the case of feed grains, maize and soybeans (Alston, Beddow and Pardey 2010).

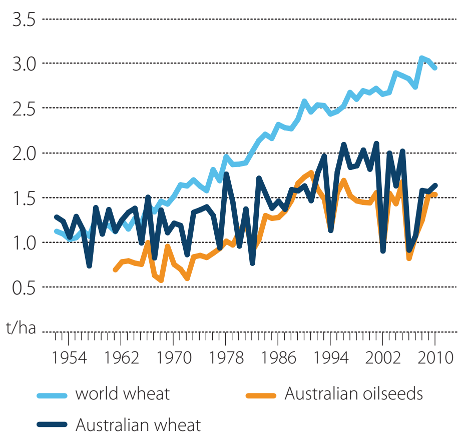
Advances in agricultural productivity have been the main factor behind increased food production in the past, and will be critically important to the ability of humankind to feed itself in the future. But productivity growth has slowed in recent years, reflecting, in part, lower investment in R&D both globally and in Australia.

9 Contribution of total factor productivity growth to the gross value of agricultural production (GVAP), 1952–53 to 2007–08



Source: Gray et al. 2011

10 Crop yields



Source: ABARE–BRS

Despite their contribution to productivity, public caution toward GMOs currently restricts their potential. In particular, their lack of acceptance in Europe reduces productivity gains there, as well as constraining their use in other countries that export large proportions of their products to Europe. This also limits the incentive to invest in R&D. The lack of acceptance in Europe is of particular concern in African countries that, as suppliers to the European Union, are unable to adopt the technologies that benefit agricultural production in many other parts of the world. Nevertheless, as discussed earlier, there is significant prospect for yield and production improvement in Africa from the adoption of known non-GM seed varieties and more modern production techniques.

For productivity gains to be fully realised, technologies need to be acceptable to consumers and others in the supply chain. Australia's commercial experience with GM crops was limited largely to cotton and carnations (Acworth, Yainshet, and Curtotti 2008), but canola has more recently gained approval for production in all producing states except South Australia.

Climate change

The potential effects of climate change on agriculture in Australia and globally were assessed by Gunasekera et al. (2007). Increasing temperature, changing rainfall patterns and an increasing frequency of extreme events are expected to reduce agricultural production below the levels it would otherwise reach (the baseline) in many, but not all, countries through the 21st century. If mitigating and adaptation actions are not taken, global wheat production in 2050 could be 5.1 per cent lower than the baseline, and beef and dairy production could each be 11 per cent lower. Agricultural production is likely to be more adversely affected in lower latitudes, where developing countries are predominantly situated; in mid to high latitudes, the impact will be less severe, and in some cases will be positive.

Although agricultural production in Australia is expected to rise substantially in the future, the extent of this rise may be lessened by the impact of climate change. Climate change mitigation policies can also have an adverse effect on agricultural production.

In Australia, rainfall levels in northern areas may change little, but Australia's major cropping and livestock production areas in the south-west could be as much as 40 per cent drier by 2070 than in 1990 (Gunasekera et al. 2007). By 2050, climate change has the potential to constrain Australian wheat production to 13 per cent below the baseline, to constrain beef production by 19 per cent, and to constrain dairy production by 18 per cent.

Agricultural trade is likely to be lower than it would be without climate change because of two factors: lower agricultural output; and lower demand influenced by the slower economic growth of trading partners. At the same time, trade will play a part in balancing the impact of global warming, allowing regions of the world with positive (or less negative) effects to supply those with more negative effects (Nelson et al 2010).

While climate change is expected to affect agriculture, agricultural activities also affect climate change. In Australia, as in many countries, there has been discussion about mechanisms to impose a price on carbon emissions. Even if agriculture were excluded from the direct imposition of a carbon tax, it would be indirectly affected through both increased prices of inputs such as fuel, fertiliser and chemicals and any pass-back of the tax on outputs such as transport and processing.

Resources for food production

While by far the greatest gains in food production have come from improvements in yields, past increases in Australian production were due, in part, to expansion of cropping areas. However, Australia's total farm area reached a peak of 500 million ha in the mid-1970s and has since declined to a little more than 400 million ha. There may be some scope for additional land to be brought into agricultural production—in northern Australia, for example—but development is likely to be limited without the stimulus of higher prices for food and significant investment in infrastructure.

At the same time, some land is being lost to urban, mining and industrial uses, and there is a risk that land could become degraded by further salinity, acidity and encroachment of pests and weeds, thus limiting the potential for increased food production.

In Africa and South America, there remains unused land that can be farmed. In some of the Newly Independent States of the former Soviet Union, land which has been taken out of cropping in the past 20 years could be reinstated (OECD–FAO 2009). However, infrastructure support remains an issue for agricultural development in those regions, and expansion would depend on price incentives. Water availability could impose more severe constraints on food production than could land availability. Competition from other users, including industry and urban households, is already intense in many countries where the expansion of irrigation has been an important driver behind increased crop yields. In the future, a substantial slowdown in the global expansion of irrigated land is expected (OECD–FAO 2009), with future gains coming from improved performance of existing irrigation.

Agricultural production requires resources such as land, labour, capital equipment, water and other inputs, including energy, fertilisers and pesticides. Agriculture competes with other sectors of the economy for some of these resources; for others, competition exists primarily among agricultural products.

Where additional resources such as unused land or water do exist, environmental considerations are likely to constrain their use.

The availability and cost of farm labour depends on the performance of agriculture relative to other sectors in the economy. Many developing countries have, in the process of economic development, seen an exodus of labour from agriculture to other industries. Currently, in Australia, competition between agriculture and other sectors, particularly the buoyant mining sector, may have implications for farm labour. Australian agriculture has paid lower wages and had difficulty recruiting the labour it needs (Sheales and Gunning Trant 2009). Technological developments, particularly in the cropping sector, have increasingly allowed the substitution of mechanical equipment for labour, and employment on Australian farms has declined from more than 400 000 in the 1960s to a little more than 300 000 in recent years (ABARES 2010).

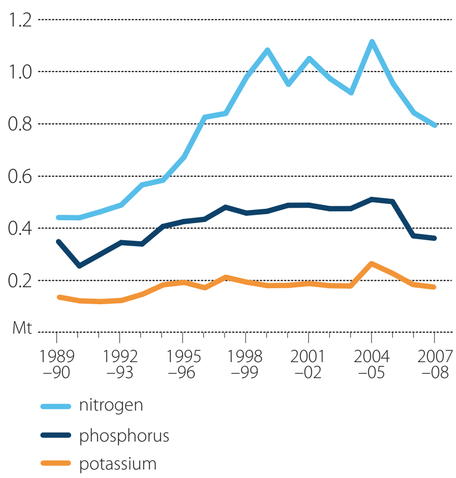
With farms predominantly owned by individual families, the capital required for mechanisation and other on-farm investment has been largely derived from within the farm business and from bank credit. A small number of larger company-owned farms have had access to equity capital, with a small proportion of these farms using overseas capital. The increasing capital requirements of agriculture might have been expected to favour increased investment by domestic and foreign companies, but this does not appear to have happened to any significant extent despite the productivity gains that might have accrued from it.

Fertilisers are essential inputs to Australian agriculture, and have been used intensively. Nitrogen in particular has been used in increasing quantities. Most of Australia's fertiliser is imported. From 2001 to 2009, imports amounted to around 56 per cent of the phosphatic fertiliser used, 77 per cent of the nitrogen used and 100 per cent of the potassium used (ABARES 2010). Phosphate rock, from which phosphatic fertilisers are manufactured, is partly imported and partly mined from domestic deposits (See box on phosphate rock reserves).

Current economic reserves of potassium amount to more than 200 years, but there are also considerable potential reserves. Nitrogen is available from the atmosphere in virtually unlimited quantities, though the cost of converting atmospheric nitrogen to fertiliser—mainly by using natural gas—is considerable. There are also limited deposits of mineral nitrates. Sulphur is considered to be available in quantities sufficient for the foreseeable future (USGS 2010).

Energy is an essential input to agricultural production. With considerable reserves of oil remaining, and with prospects for the further development of alternative sources of energy, it seems unlikely that food production will be constrained by any physical limits to energy availability. However, the price of energy can be expected to increase in real terms, and the costs of using it to be further increased by carbon trading or tax arrangements. There have been linkages made between price rises in energy and also for food. These linkages could also be important for future price movements.

11 Fertiliser use, Australia



Source: ABARES *Australian commodity statistics*

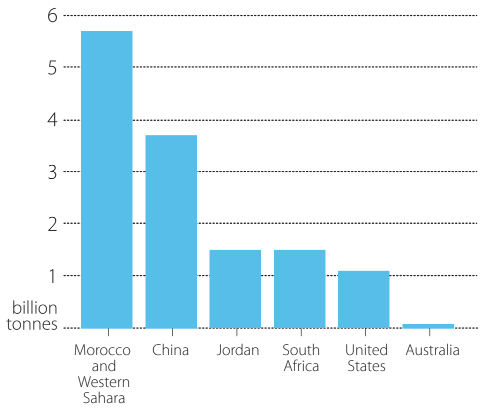
Fishery resources are also important determinants of future food production. With fish stocks under threat, there may be little capacity for increased production of capture fish over the longer term. Consumption of fish is particularly important in some countries, such as Japan and Norway, and it is a significant although smaller part of global food consumption, constituting around 6 per cent of protein intake and 1 per cent of calorie intake at the world level (FAO 2010a). Aquaculture now constitutes 36 per cent of total fish production (OECD–FAO 2009) and is expected to continue to grow.

Box 1 Phosphate rock reserves

At the present rate of extraction, current global reserves of phosphates that can be economically extracted would be sufficient for around 100 years with current usage patterns. Additional reserves, which cannot be economically extracted at present, amount to several times that quantity, and large undersea reserves are also known to exist (USGS 2010). Australia has relatively small deposits of phosphate rock. Of the major plant nutrients, phosphorus appears to be the one with some potential for shortfalls in supplies to generate significant price increases, particularly as reserves occur in a relatively small number of countries, notably China and Morocco.

However, there are new technologies for the more efficient application of fertiliser, where the application rate is varied in accordance with soil requirements. In the longer term, development of new plant varieties should reduce the need for fertilisers, while possibilities exist for recycling minerals from human waste. As higher prices give an incentive for exploration, discoveries of additional reserves are also possible.

12 Phosphate rock reserves



Source: US Geological Survey 2010

Competition for resources – non-food agricultural production

Agriculture has traditionally been the source of non-food commodities such as cotton, wool and other vegetable and animal fibres; rubber; beverages; industrial oils; tobacco; and forestry products. Traditionally, these commodities have competed with food production for agricultural land, but more recent developments now see intensified competition between food and non-food applications of the same crops. The recent expansion in production of biofuel, particularly ethanol, has been of considerable importance, and other products of the so-called 'biobased economy', including bioplastics, pharmaceuticals and lubricants, could become more significant in the future (Langeveld, Dixon and Jaworski 2010). All these commodities contribute to the income, and hence the food security, of the farmers who produce them. However, they employ resources that could otherwise be used for food production.

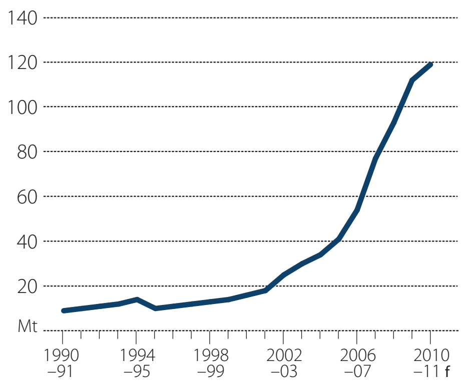
Biofuels are of particular interest because they have been promoted by government subsidies and mandates, particularly in the United States and Europe as well as in Australia, and have recently had a considerable impact on markets. Rosegrant (2008) estimated that 30 per cent of the increase in cereal prices between 2000 and 2007 was attributable to demand for ethanol production.

Increasing production of biofuel, together with traditional production of other non-food commodities, compete with food for resources and can contribute to reduced supplies and higher prices of food.

While the higher food prices stimulated by biofuel production have obvious negative implications for poor food-importing countries and households, the medium to longer term implications may be different. Where a positive supply response is possible, the higher prices will stimulate production, in importing as well as exporting countries, with 'potentially positive implications for economic growth, poverty reduction and food security' (FAO 2008).

Biofuel production in Australia is small but has the potential to become more significant. In the United States, almost one-third of corn produced or one-quarter of all cereal produced is used to produce ethanol. Globally, ethanol production is forecast to grow at 6.6 per cent annually in the period to 2018, and biodiesel at a faster rate of nearly 9 per cent annually (OECD–FAO 2009). This growth will be driven largely by government mandates and subsidies rather than commercial incentives, and will continue to place upward pressure on food prices. Mandates in particular override the normal working of the market and can be expected to increase prices and to contribute significantly to food price instability.

13 US corn used in ethanol



f ABARES forecast
Sources: USDA , Economic Research Service

The longer-term future of biofuel production is difficult to predict, as the policies that drive it may prove to be more transient than the underlying economic and commercial reality. It is likely that the introduction of second-generation technology, using cellulosic rather than starchy material as feedstock, would have different implications for food security, possibly offering greater opportunities to developing countries while posing a smaller threat to food supplies.

Concluding comments

The global food security challenge is not about the capability of world agricultural producers to produce enough food to feed the world, but rather is about ensuring that the poorest people in the world have the economic and physical access to the food they require to meet their nutritional needs.

Australia is able to produce sufficient food to meet its needs and has the income to achieve national food security. Australia's prosperity, coupled with its participation in the global economy, will ensure this food security for the foreseeable future.

Australia has a role in global food security but this is not principally in producing food for the world's food deficit countries. Australia will feed far more of the world's poor by providing technical assistance that helps them in feeding themselves, thereby enhancing their economic development and thus their ability to afford food.

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Productivity Commission

Trends in Australian Agriculture

Productivity Commission Research Paper

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The Productivity Commission

The Productivity Commission, an independent agency, is the Australian Government's principal review and advisory body on microeconomic policy and regulation. It conducts public inquiries and research into a broad range of economic and social issues affecting the welfare of Australians.

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Foreword

Australian agriculture has undergone considerable change over the last few decades. Thanks to rapid productivity growth, agricultural output has more than doubled in this period. Nevertheless, with the even faster growth of the services sector, agriculture's share of the economy has declined. At the same time, there have been marked changes in the make up of the sector, driven by a variety of domestic and international forces.

This report examines some of the key trends in Australia's agriculture sector over the last 20 years or so. The report is part of a series tracing developments in different sectors of the Australian economy. Previous studies have looked at trends in manufacturing (PC 2003) and services (McLachlan et al. 2002).

The Commission is grateful to all those who provided assistance in the preparation of this study and welcomes further feedback on it.

Gary Banks
Chairman

June 2005

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Abbreviations

ABARE	Australia Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AMS	Aggregate Measurement of Support
ANZSIC	Australia and New Zealand Standard Industrial Classification
ASEAN	Association of South East Asian Nations
ASGC	Australian Standard Geographical Classification
ASIC	Australian Standard industrial Classification
BOP	Balance of Payments
BTRE	Bureau of Transport and Regional Economics
DFAT	Department of Foreign Affairs and Trade
EVAO	Estimated Value of Agricultural Operations
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IAC	Industries Assistance Commission
IC	Industry Commission
MFP	Multifactor Productivity
NCC	National Competition Council
NEC	Not Elsewhere Classified
NFF	National Farmers' Federation
NLWRA	National Land and Water Resources Audit
OECD	Organisation for Economic Cooperation and Development
PC	Productivity Commission
PPP	Purchasing Power Parities
PSE	Producer Support Estimates
RBA	Reserve Bank of Australia
RIRDC	Rural Industries Research and Development Corporation

SITC	Standard International Trade Classification
SMAs	Statutory Marketing Arrangements
TREC	Trade Export Classification
VET	Vocational Education and Training
WTO	World Trade Organization

OVERVIEW

Key points

- Agriculture has undergone much change over the last few decades. Key drivers have been shifts in consumer demand, changes in government policies, technological advances and innovation, emerging environmental concerns and an unrelenting decline in the sector's terms of trade.
- While historically agriculture played a dominant role in the economy — its *relative* importance has declined in recent decades.
- That said, in *absolute* terms, real agricultural output has more than doubled over the four decades to 2003-04. And agricultural exports have almost tripled in value (real terms) since the mid 1970's.
- In 2003-04, the sector directly generated 4 per cent of GDP and employed 375 000 people or 4 per cent of the workforce. It looms larger in Australia's exports, accounting for around 22 per cent of total exports in 2003-04.
- Farms are much fewer and larger than twenty years ago. Production is increasingly concentrated on larger farms, accentuating the dual nature of the sector (with a few large commercial farms accounting for the majority of output and many farms accounting for a small share of output).
- Agriculture has become increasingly export oriented over the last two decades — around two-thirds of production is now exported. Exports have also become more diverse, with less reliance on traditional commodities such as wool and more on processed products such as wine, cheese and seafood.
- The agricultural workforce has a number of distinctive features, including: a high proportion of self-employed, family and casual workers; long job tenure; and a relatively old workforce with relatively low education levels and employee wages.
- The last two decades have seen an increase in the number of employees and a fall in employers and contributing family workers. The educational attainment of workers has also improved.
- Off-farm employment has become increasingly important to maintaining family farm incomes. Since 1990, the proportion of farm families deriving income from off-farm wages and salaries increased from 30 to 45 per cent, with average earnings rising from $15 000 to $33 500 per year.
- Agricultural productivity has exhibited strong growth over the last three decades — more than twice the rate achieved in Australia's market sector as a whole.
- Productivity growth has accounted for the entire increase in output by the agriculture sector over the last 30 years.
- Performance within the sector has been mixed — over the last three decades the cropping industry recorded the highest productivity gains, and the sheep and sheep-beef industries the lowest.

Overview

Australia's agriculture sector has undergone considerable change over the last few decades. While continuing to grow in absolute terms, the size and importance of agriculture has declined relative to the rest of the economy. Within the sector, there have been marked changes in the number and size of Australian farms, the make-up of agricultural activities and the production and marketing strategies employed by farmers.

Some of the key factors shaping these trends have been changes in consumer demands and government policies, technological advances and innovation and emerging environmental concerns. The unrelenting decline in the sector's terms of trade (that is, the ratio of prices received to prices paid) has been an important source of pressure for adaptation and change by Australian farmers. The sector has also had to respond to the continuing challenge of variations in seasonal conditions.

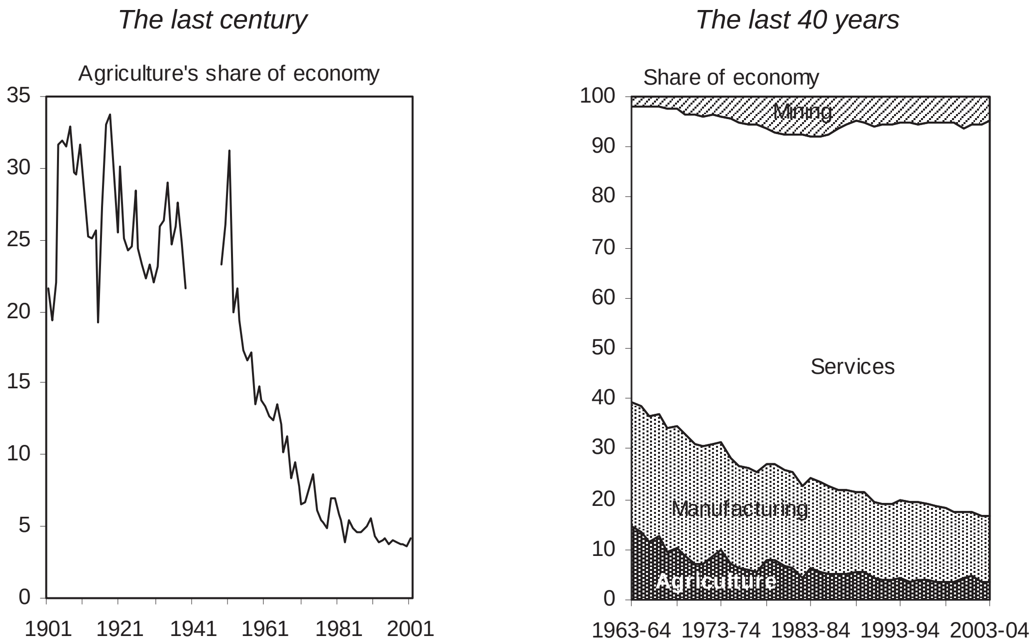
The importance of agriculture to the economy

Historically, agriculture has played an important role in the Australian economy. In the first half of the 20th century, it accounted for around a quarter of the nation's output and between 70 and 80 per cent of Australia's exports. There was then considerable force in the old saying that the Australian economy 'rode on the sheep's back'.

Since then, however, agriculture's *relative* importance within the economy has been in steady decline.

- Agriculture's share of GDP fell from around 14 per cent in the early 1960s to 6 per cent in the early 1980s. Over the last two decades, it has ranged from between 4 and 6 per cent (figure 1).
- Agriculture's share of employment has more than halved since the late 1960s when it accounted for around 9 per cent of the workforce.
- Australia's reliance on agricultural exports declined from over two-thirds of total exports in the early 1960s to just over one-fifth in 2003-04.

Figure 1 **Agriculture has declined in *relative* terms**



The relative decline in agriculture has several causes, notably:

- the growth in consumer expenditure being directed predominantly to services as national income has risen;
- a decline in the price of agricultural commodities relative to other goods and services; and
- relatively high productivity growth in agriculture, which has been critical to the sector's performance, but also facilitated the release of resources to other sectors of the economy.

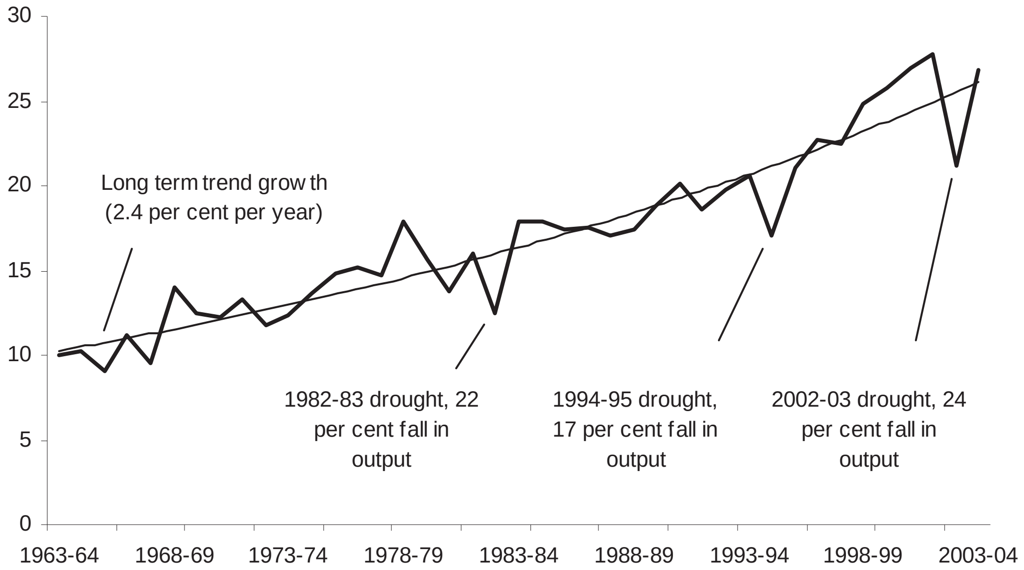
As such, the declining share of agriculture is more a reflection of success rather than any systemic weakness. It is consistent with the experiences of other developed countries — there is a strong inverse relationship between per-capita income, GDP and employment shares accounted for by agriculture. That said, Australia's agriculture sector's share of output remains one of the highest in the OECD.

Output has increased in absolute terms

The decline in agriculture output is a relative phenomenon. Real output in agriculture actually increased by around two and half times over the four decades to 2003-04 (figure 2).

Figure 2 **Growth in agriculture output, 1963-64 to 2003-04**

Value-added ($ billion, constant 2002-03 prices)



This increase in output was achieved without an increase in the number of agricultural workers, reflecting strong productivity growth in the sector. In fact, in trend terms, agricultural employment has been relatively flat over the last forty years — declining by less than half of one per cent a year.

Agricultural exports have also grown in real terms — since 1974-75 they have almost tripled in value, increasing at a trend annual rate of 3.5 per cent a year.

…and agriculture continues to play an important role

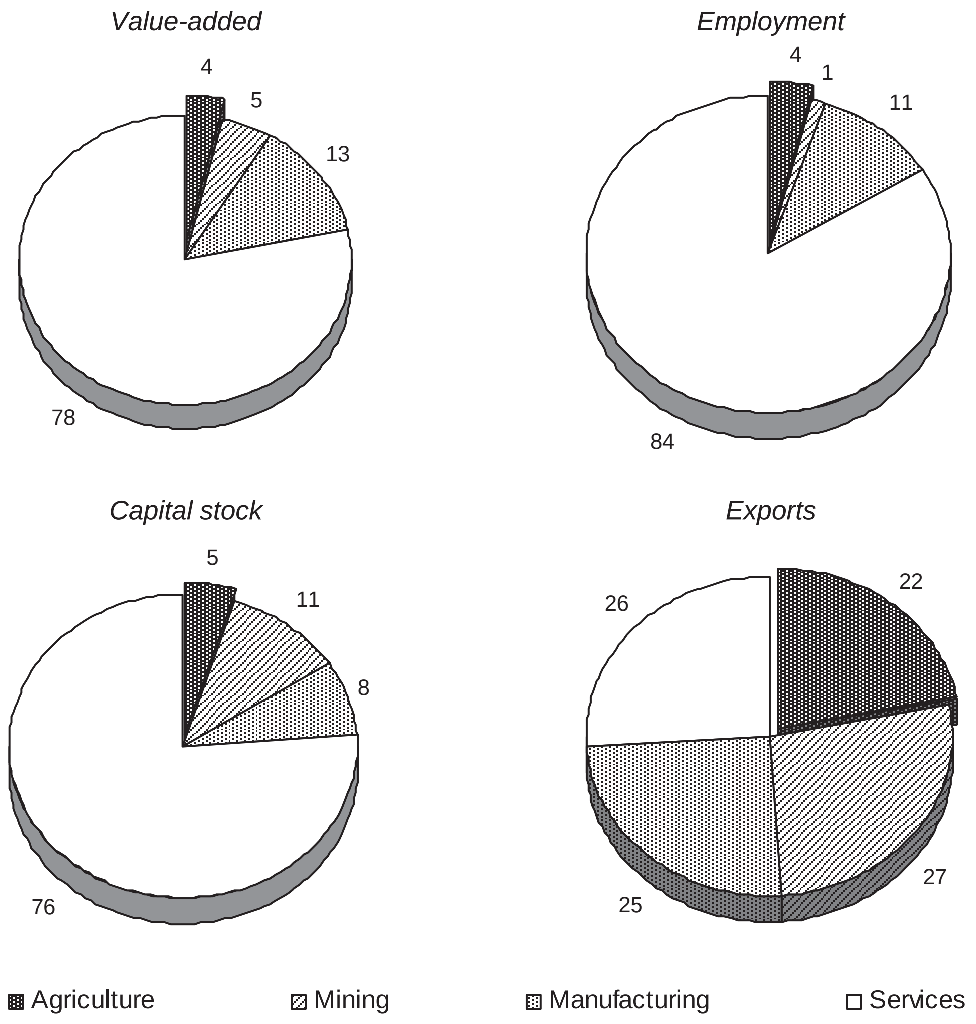
While declining in relative importance, agriculture's contribution to the Australian economy remains substantial (figure 3). In 2003-04, agriculture directly:

- contributed 4 per cent or $25 billion of the total output of the economy;
- employed 375 000 people or around 4 per cent of the workforce; and
- accounted for around 5 per cent of Australia's investment effort and employed a similar proportion of Australia's net stock of capital.

Agriculture plays a much bigger role in Australia's exports than might be expected given its output share. In 2003-04, it directly accounted for around 22 per cent of Australia's total goods and service exports.

Figure 3 **Agriculture's contribution to Australian economic activity, 2003-04**

Per cent



Agriculture is characterised by substantial volatility in output over time, with fluctuations in climatic conditions, such as droughts, substantially impacting on output in some years. Over the last three decades, agriculture has recorded the highest level of volatility in year-to-year output growth of all industries (more than two and a half times higher than the average for all industries).

And, variations in the sector's fortunes can have significant flow-on effects for the economy. The 2002-03 drought, for example, saw agricultural output and exports decline by almost one-quarter and employment fall by around 15 per cent (box 1). This in turn reduced Australia's GDP and employment growth by around 1 percentage point. In the same year, agriculture multifactor productivity (MFP) declined by around 17 per cent, thus reducing aggregate MFP growth by around 1 percentage point (or around half of the market sector MFP growth).

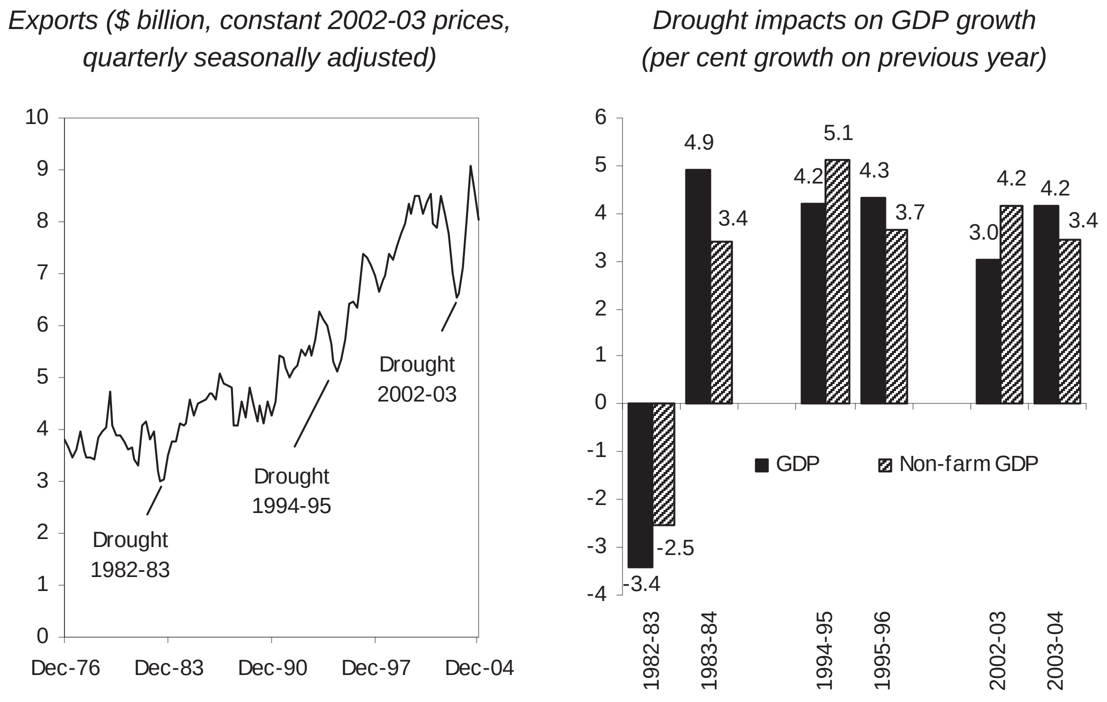
Box 1 **Impacts of drought on employment, exports and GDP**

Droughts periodically have a substantial impact on agricultural output, with flow-on effects for employment and exports (figure 4). The 2002-03 drought, for example, saw the loss of around 70 000 agricultural jobs, or a decline of around 15 per cent. This 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 2002-03 drought also had a substantial impact on agricultural exports — a fall of around 23 per cent (or $2 billion) between the June quarter of 2002 and the June quarter of 2003. As with other droughts, however, recovery was rapid, with increases in export volumes of almost 40 per cent ($2.5 billion) between the trough in the June quarter of 2003 and the June quarter of 2004. Latest export data indicate that agricultural exports have been declining over the course of 2004-05 — with a 10 per cent fall between the peak in the June quarter 2004 and the December quarter 2004.

Droughts can also impact on measured growth rates for the economy (figure 4). A comparison of growth rates for GDP and non-farm GDP shows that during the last three droughts agriculture shaved around one percentage point off GDP growth.

Figure 4 **Droughts, agricultural exports and GDP growth**

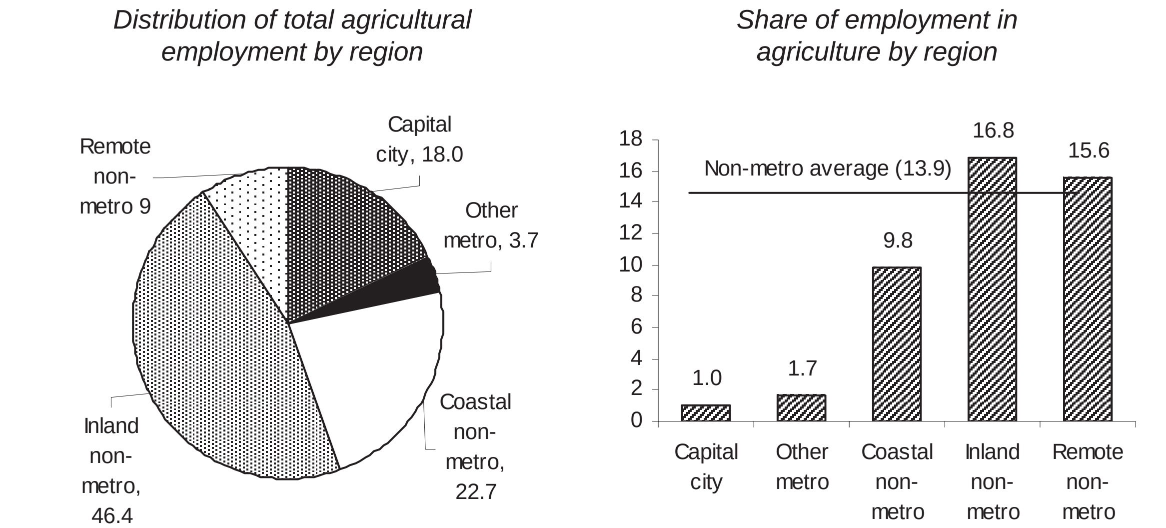


An important employer in rural and regional Australia

Agriculture remains a dominant employer in rural and regional Australia. In 2001, almost 80 per cent of agricultural employment was in non-metropolitan regions.

Almost 10 per cent of those employed in coastal non-metropolitan regions and more than 15 per cent of those employed in inland and remote regions were employed in agriculture (figure 5). In the same year, over a third of all employment in the food processing industry was located in non-metropolitan regions.

Figure 5 **Agricultural employment shares by region, 2001**
Per cent



For 207 of Australia's 425 labour regions, agriculture accounted for over 25 per cent of total employment in 2001.

Changes *within* agriculture have been profound

Fewer and larger farms

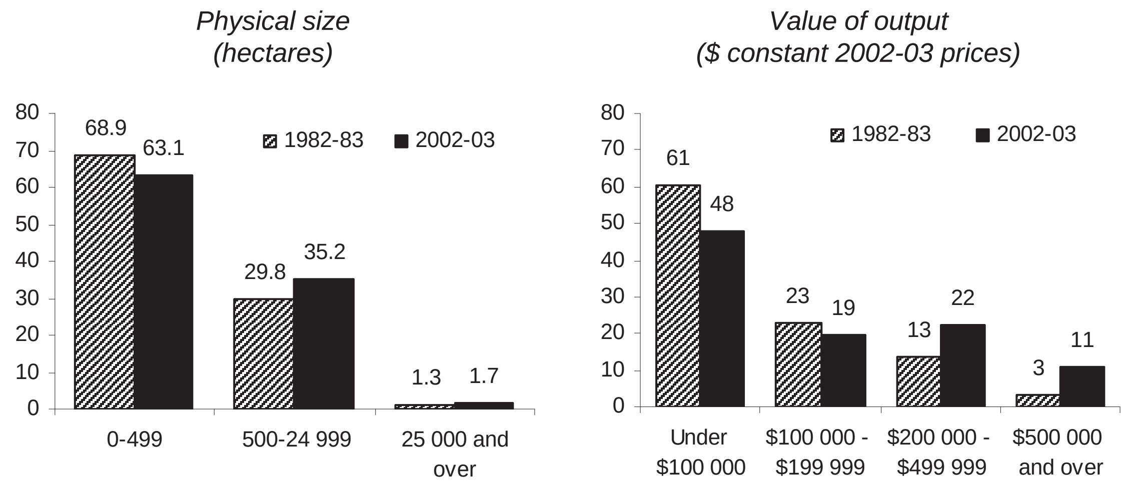
Consistent with global trends, farm numbers in Australia declined by around one-quarter (or by almost 46 000 farms) over the twenty years to 2002-03.

Accompanying this decline has been a reduction in the area of land in agricultural production and an increase in the average size of farms. Over the twenty years to 2002-03:

- the area of land under agricultural production declined by around 9 per cent;
- the average farm increased in size from 2720 hectares to 3340 hectares — an increase of some 23 per cent;
- the proportion of farms in the 'small' farm size category declined, while the share of medium sized farms increased; and

- the proportion of farms with a value of operations of less than $100 000 declined, while the proportion of farms with a value of operations over $500 000 increased (figure 6).

Figure 6 **Distribution of farms by size, 1982-83 and 2002-03**
Per cent



The increase in farm size — in terms of both physical size and value of output — has been most evident in the cotton, grains and pig industries.

... but there are many more small farms

Notwithstanding the trend towards larger farms, small farms continue to dominate the count of farms in Australian agriculture (figure 6, box 2).

Intensive production system industries, such as nurseries, egg and poultry meat farming, have a relatively high proportion of farms occupying small amounts of land. Farms using large areas of land are those based on the grazing of livestock and extensive grain production.

Beef cattle and sheep farms, however, make up a high proportion of the farms with a value of output of less than $22 500. Other industries with a relatively high proportion of farms in this category include fruit and vegetables, grape growing, horse farming, nurseries and cut flowers. In contrast, farms engaged in cotton growing, poultry raising, egg production and pig farming have a high proportion of farms with a value of output of more than $500 000.

Box 2 Facts about the size of Australian farms

Australian farms range in size from small hobby and horticultural properties to large grazing and cropping farms.

In 2002-03:

- farms under 50 hectares accounted for around 20 per cent of farms (25 400);
- 33 per cent of farms were sized between 100 and 499 hectares;
- farms over 2500 hectares accounted for 11 per cent of all farms;
- the median estimated value of operations (EVAO) of all Australian farms was $109 000; and
- around 17 per cent of farms (21 600) had an EVAO below $22 500, while around 11 per cent (14 100) had an EVAO of more than $500 000.

Increased concentration of output

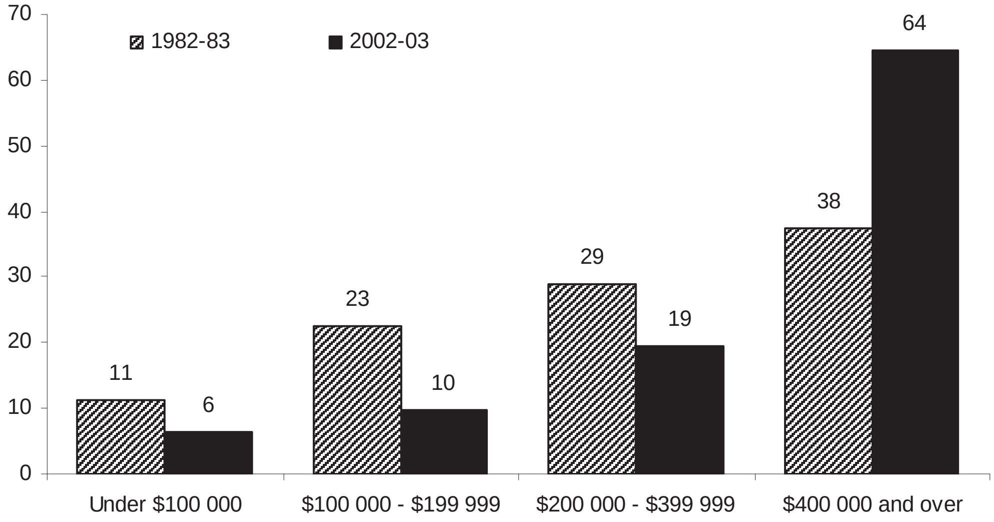
Agricultural production has also become more concentrated on large farms. It is estimated that 10 per cent of Australian farm businesses now produce over 50 per cent of output. In contrast, the smallest 50 per cent of farms account for just 10 per cent of gross farm output.

ABARE data covering broadacre farming provide clear evidence of this development. Over the last two decades:

- the proportion of farms in the largest size category (based on value of operations, at constant prices) increased by 10 percentage points to 20 per cent; and
- the share of value of farm production produced by these farms increased from 38 to around 64 per cent — almost three times the increase in the proportion of farms in this category (figure 7).

Figure 7 **Share of the value of broadacre farm production by value of output, 1982-83 and 2002-03**

Per cent (constant 2002-03 prices)



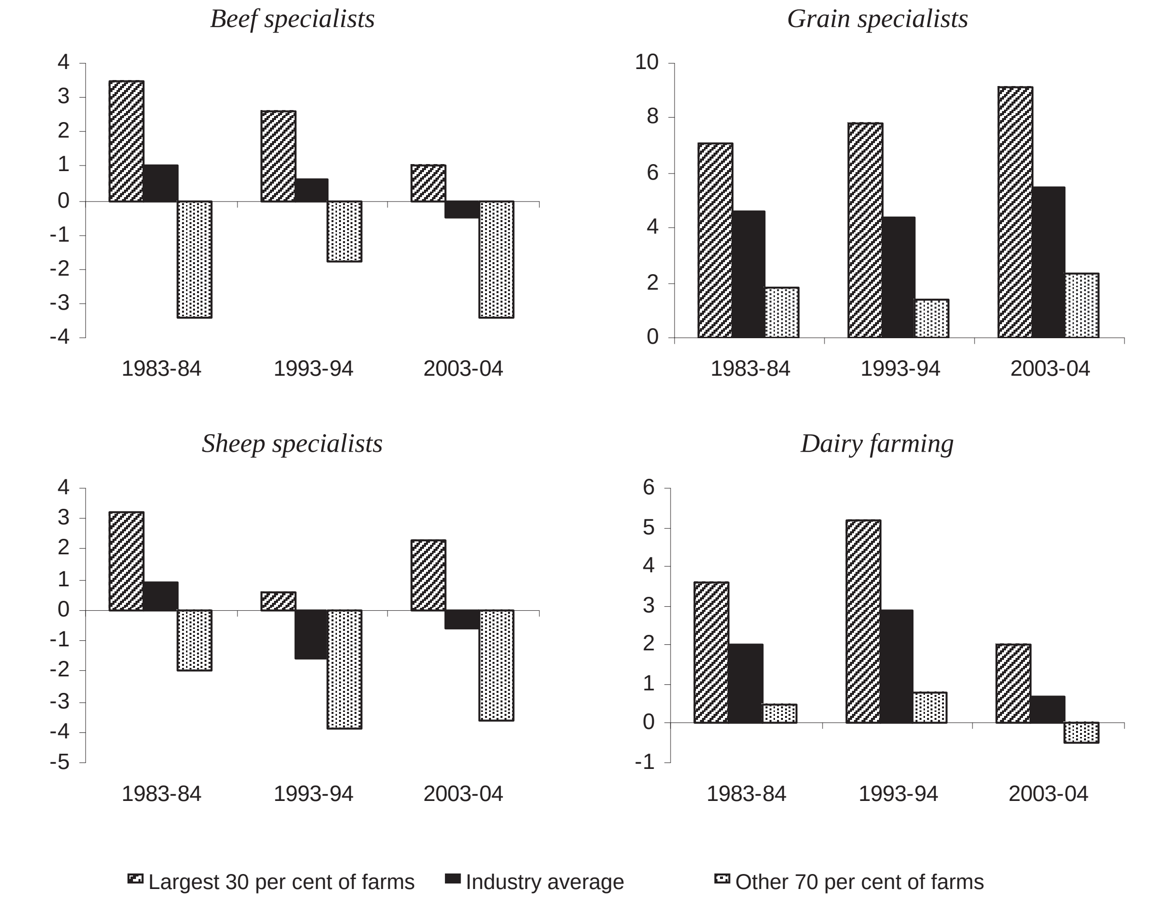
There is, however, some variation in the level of concentration across different industries. In the beef industry, for example, in 2003-04, the top 30 per cent of farms (in terms of value of output) produced more than 80 per cent of industry output, while in the grains and dairy industries the top 30 per cent produced around 60 per cent of output.

The trend towards increased concentration of output has accentuated the dualistic nature of Australia's agriculture sector — where a small number of large scale commercial farms produce the majority of agricultural output, while small-scale or niche farms (which make up an overwhelming majority of farms) account for only a small proportion of output. Many of these smaller farms tend to be operated by 'lifestyle farmers' and are particularly prevalent on the fringes of major metropolitan and regional centres.

… and performance varies by farm size

Similarly, while average rates of return vary across agricultural industries (and between years), they hide significant divergences (figure 8). In particular, relatively low average rates of return mask the strong performance of large commercial farms (and those that generate the majority of output). Average rates of return generated by larger broadacre farms are generally comparable with investment returns elsewhere in the economy.

Figure 8 **Farm size and rate of return, 1983-84, 1993-94 and 2003-04**
Per cent

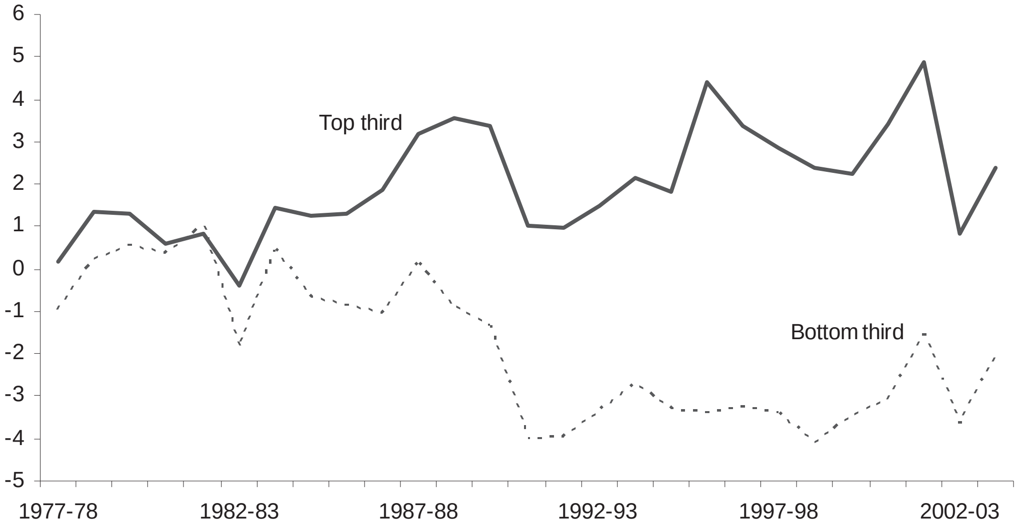


And, when farms are ranked using sheep equivalents[1], the gap between the rates of return generated by the top and bottom third of farms has increased over the last 25 years (figure 9). With such financial outcomes, the continued prevalence of small farms can in part be attributed to the increasing importance of off-farm income.

[1] The sheep equivalent measure is widely accepted as an indicator of the productive capacity of farms in different industries. It allows comparisons on an equivalent basis of the size of a farm by reflecting the differing feed requirements of various livestock and/or the equivalent potential capacity of land used for cropping purposes.

Figure 9 **Divergent rates of return for broadacre farms, 1977-78 to 2002-03**

Per cent

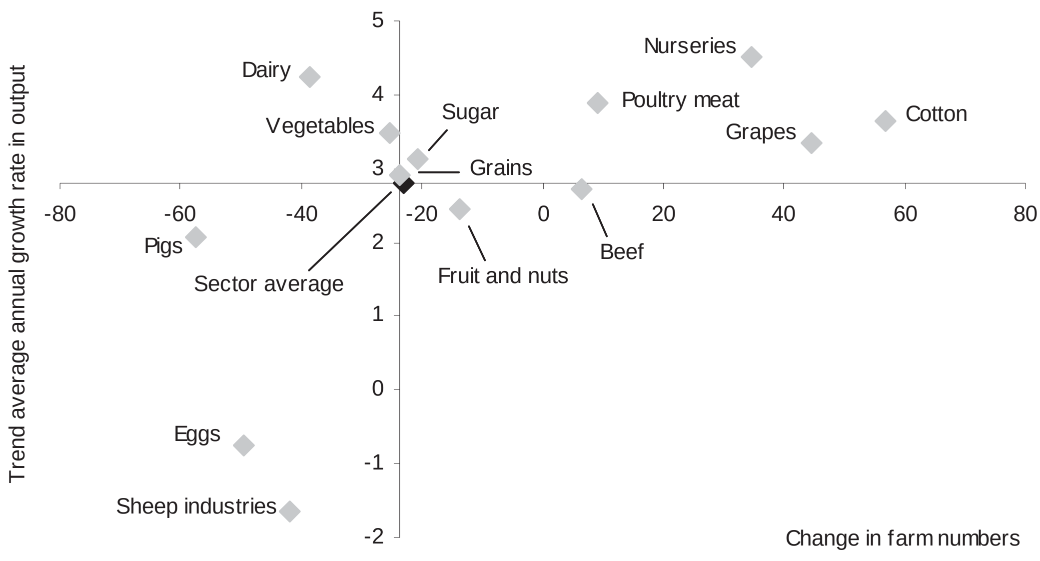


Diversity in industry trends

An examination of output growth rates and changes in farm numbers by industry since the mid-1980s reveals considerable diversity across the agricultural sector. Three broad groups can be identified:

- average performing industries (recording output growth rates and changes in farm numbers broadly in line with the sector average) — beef, grains, fruit and nuts, vegetables and sugar;
- slow or declining growth industries — pigs, eggs and sheep; and
- high growth industries — poultry, grapes, cotton, nurseries and dairy. With the exception of dairy, industries in this group also recorded increases in farm numbers (figure 10).

Figure 10 **Value of output and farm number growth, 1985-86 to 2002-03**
Per cent



Other notable trends within agriculture

The last twenty years have also seen a shift towards more intensive farming. This trend is reflected in both a structural shift to enterprises using more intensive production systems (such as poultry, grapes, cotton and nurseries) and the adoption of more intensive production techniques (increased use of feed, chemicals and irrigation).

Agriculture has also become more closely integrated within the agri-food chain. An increasing proportion of agricultural output, for example, is now supplied to processors or major retailers under comprehensive pre-arranged contracts. In part, this shift has been facilitated by the unwinding of statutory marketing arrangements in many agriculture industries, allowing farmers greater control and choice in the management and marketing of their output.

More demand-responsive production is also evident in terms of greater output diversification, with Australian farmers now producing a wider range of commodities than previously. There has also been an increase in the number of varieties of the same crop and breeds of livestock produced for different markets.

Agricultural trade

While the economy's reliance on agricultural exports has been declining, with little or no domestic consumption growth, Australia's agricultural industries have become more heavily export oriented over the last twenty years (figure 11).

Around two-thirds of agricultural production is now either directly or indirectly exported. The dependence on exports, however, varies among industries. The wool industry, for example, currently exports around 95 per cent of its production. The beef, sugar and wheat industries export around 65-75 per cent of their production, while the sheep meat, wine and dairy industries export around 50-60 per cent. With the exception of the wool industry — which has always been highly export oriented — these shares have all risen steadily in recent decades.

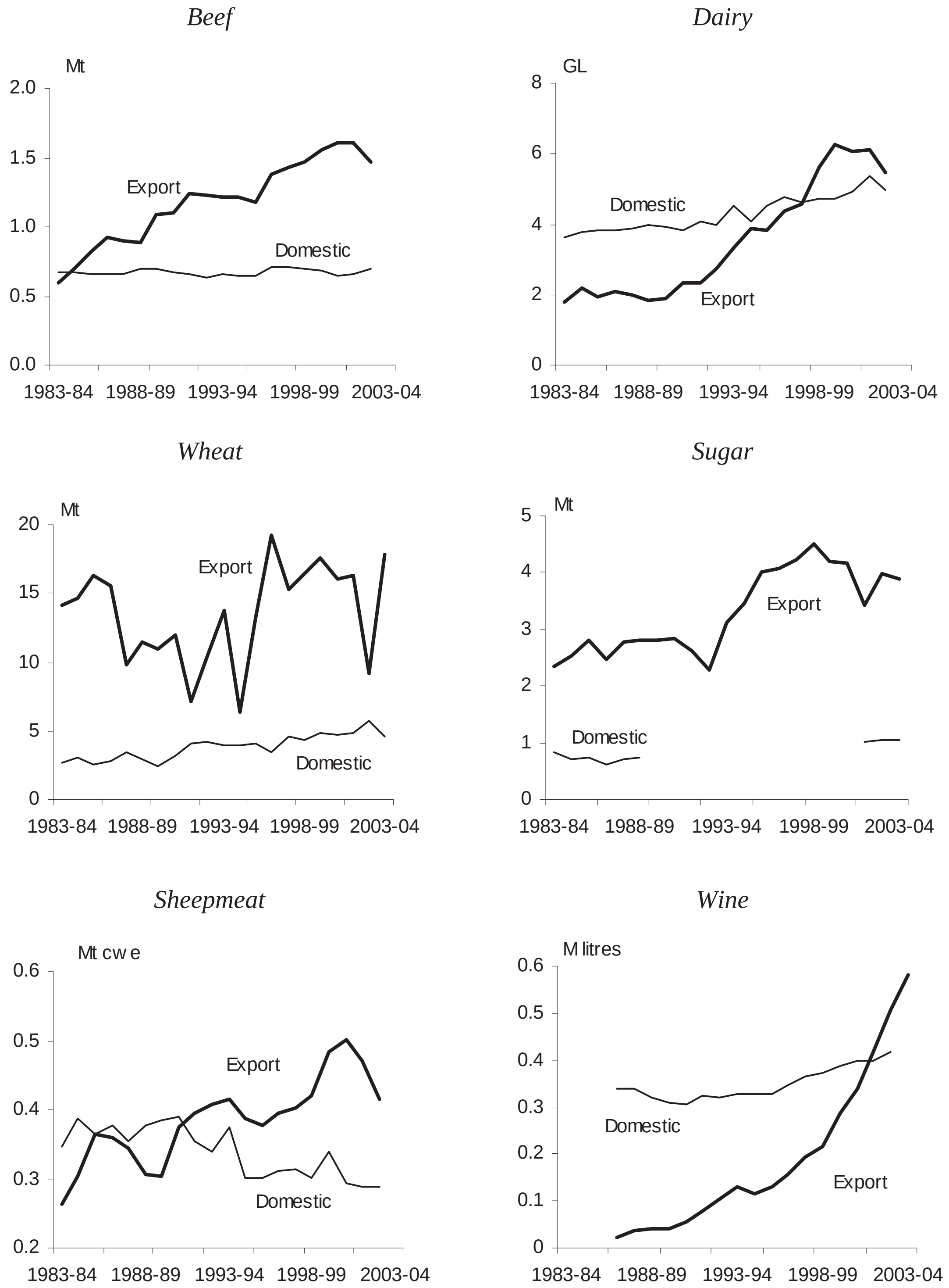
The changing industry mix of agricultural exports

Australia's agricultural export profile has become more diverse in recent decades with less reliance on traditional commodities, such as wool, and more reliance on processed agricultural products (such as wine, cheese and seafood, box 3).

In 1969-70, the 'big three' agricultural exports — wool, cereals and meat — accounted for almost four-fifths of the value of agricultural exports. By 2003-04, their combined share had fallen to around half. This largely reflects the sharp fall in the share of wool and sheepskin exports — from almost 40 per cent of agricultural exports in 1960-70 to 10 per cent in 2003-04.

Other rural exports — which include a range of processed foods such as dairy products, tinned and frozen food as well as animal feed, wood chips and other inedible products — increased from 16 to 39 per cent of agricultural exports over the same period. Beverage exports (of which wine comprised 95 per cent of total exports in 2003-04) increased from less than half of one per cent in 1969-70 to over 9 per cent in 2003-04.

Figure 11 **Australian domestic and export markets for selected commodities, 1983-84 to 2003-04**



Box 3 Some facts about agricultural trade

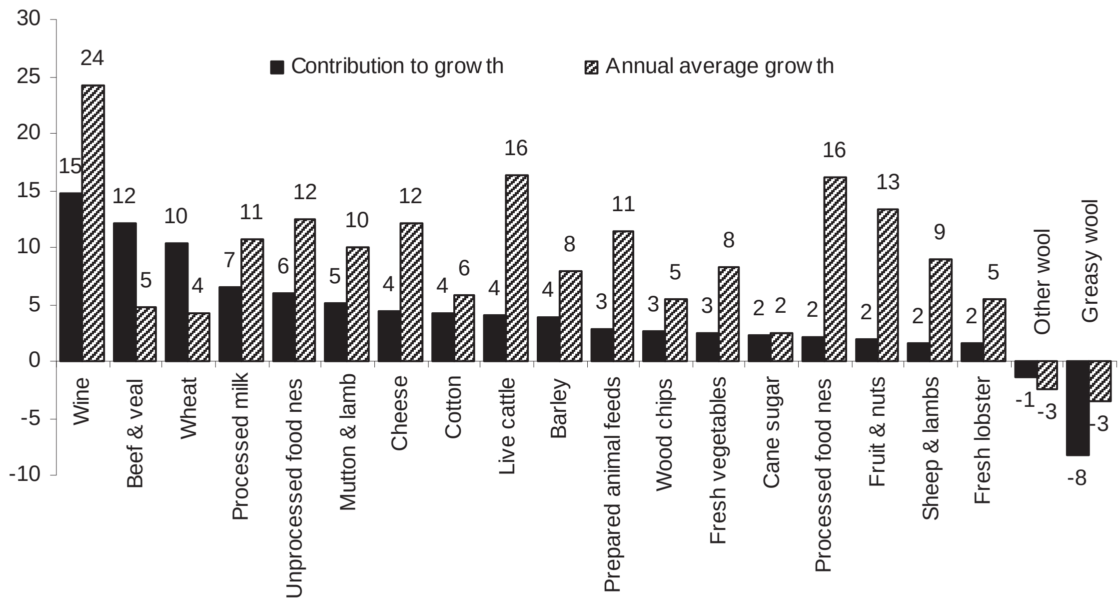
- In 2003-04:
  - agricultural exports earned $28.2 billion — amounting to 22 per cent of the value of total goods and services exports;
  - agricultural products made up 7 of Australia's top 20 export earners;
  - the top five agricultural export earners were beef and veal ($3.9 billion), wheat ($3.4 billion), wine ($2.5 billion), wool ($1.9 billion) and processed milk ($1.1 billion). Combined, these industries accounted for 45 per cent of total agricultural exports. This compares with 65 per cent for the top five agricultural export commodities in 1988-89; and
  - imports of agricultural commodities into Australia amounted to almost $8 billion, around one-quarter of the value of agricultural exports and around 7 per cent of total merchandise imports.
- Australia is now the fourth largest exporter of wine in the world after France, Italy and Spain. The value of Australian exports increased from $116 million in 1988-89 to $2.5 billion in 2003-04 — an annual rate of growth of 24 per cent.
- In 2002, Australia was the 6th largest exporter of agricultural products, accounting for around 3 per cent of global agricultural exports. By comparison, Australia was the 16th largest exporting nation overall, accounting for only 1 per cent of world merchandise exports.
- Australia is an important global player in a number of agricultural commodities. In 2002, Australia accounted for 65 per cent of global wool exports (greasy and scoured); 15 per cent of wheat exports; 15 per cent of bovine meat exports and 9 per cent of wine exports.

Annual average growth rates and commodity contributions to growth between 1990-91 and 2003-04 indicate considerable diversity in the performance of the top 20 agricultural exports (figure 12). The five largest contributors to overall growth accounted for half of total growth — comprising wine (15 per cent), beef and veal (12 per cent), wheat (10 per cent), processed milk (7 per cent) and unprocessed food (6 per cent).

A number of smaller industries — including mutton and lamb, cheese, live cattle, prepared animal feeds, processed food and fruit and nuts — also made strong contributions. All these industries recorded double digit annual growth rates with small, albeit growing, contributions to overall growth. Combined, they accounted for almost one-fifth of total export growth.

Figure 12 **Top 20 agricultural export commodities — contribution to growth and growth rate, 1990-91 to 2003-04**

Per cent, average three years ended (value terms)



The only industries to record substantial falls in export values over the period were greasy wool and other wool products, with annual average falls of around 3 per cent.

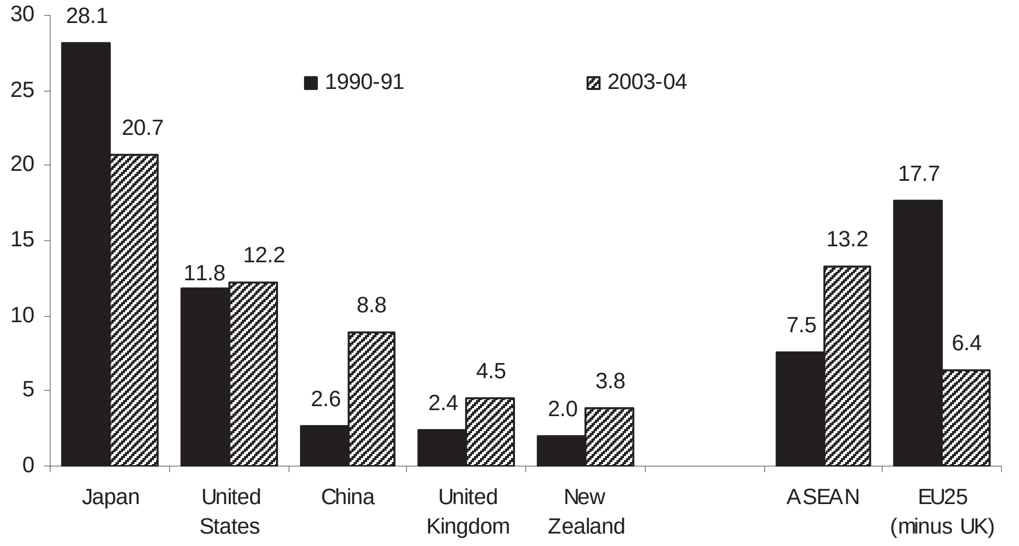
Changes in export markets

Australia's trade in agriculture is heavily influenced by sales to three key markets — Japan, the United States and China. Collectively, these markets accounted for 42 per cent of agricultural exports in the three years to 2003-04 (figure 13). Beyond these markets, trade in agriculture is dispersed among a wide range of countries. For example, the next 17 largest markets accounted for a further 42 per cent of agricultural exports.

Despite growth in agricultural exports to Japan (Australia's largest agricultural export market), the country's share of Australian agricultural exports declined by more than 7 percentage points over the period 1990-91 to 2003-04. This was largely due to a combination of declining wool prices and volumes and slow growth in the Japanese economy. The United States, China, the United Kingdom and New Zealand increased their share of Australian agricultural exports over the period. The stand out was China, which more than tripled its share over the period.

Figure 13 **Australia's top export markets, 1990-91 and 2003-04**

Per cent, average three years ended (value terms)



Australia has increasingly directed its agricultural exports to Pacific rim countries and away from European markets. The key factors driving these changes were the formation of the European common market and the loss of preferential access for Australian farmers when the United Kingdom acceded to the European Economic Community in 1973. The move away from European Union countries has, with the exception of the United Kingdom, continued in recent decades. Not only did the European Union's share (excluding the United Kingdom) of Australian agricultural exports fall 11 percentage points between 1990-91 and 2003-04, but the overall value fell by almost $0.6 billion.

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.

Barriers to growth in agricultural trade

With only limited scope for domestic consumption growth, the agriculture sector's future growth is highly dependent on increasing its sales to world markets. There are, however, significant institutional impediments to growth in agricultural trade arising from the agricultural support policies of many countries.

Despite some progress in reducing these impediments in recent decades, worldwide, agriculture continues to be the most highly protected sector. Producer support as a share of gross farm receipts among OECD countries is highest in Switzerland, Norway, Iceland, Korea, Japan and the European Union. In contrast, Australia provides the second lowest levels of support to agriculture, after New Zealand, among OECD countries (box 4).

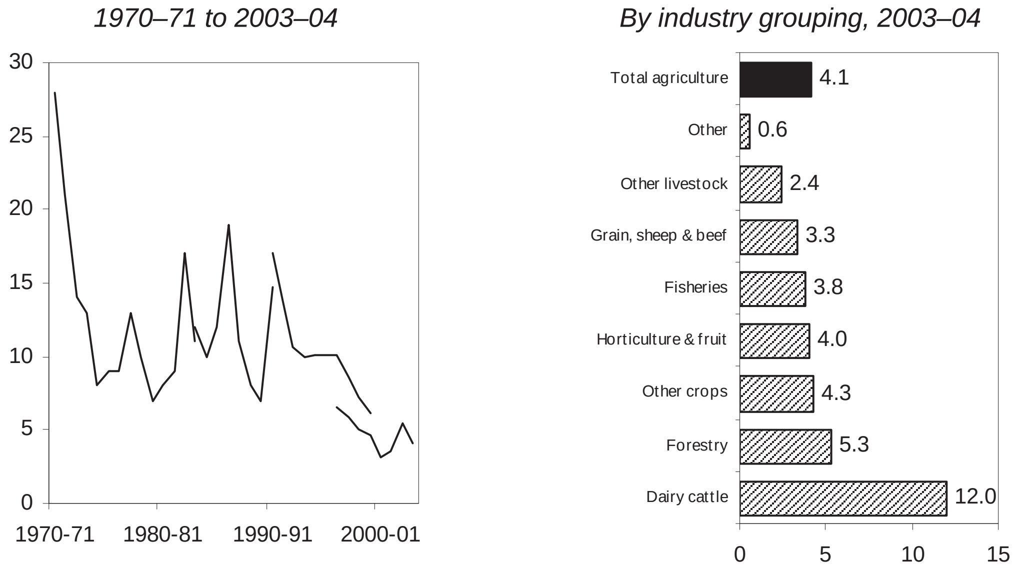
Box 4 **Government assistance to agriculture**

Australian Governments have employed a wide range of measures to assist agricultural activities. 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 14), although this figure excludes 'exceptional circumstances' drought payments.

The latest data series reveals that agriculture's ERAs have declined by 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 14 **Average effective rates of assistance to agriculture**[a]
Per cent



[a] The effective rate 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.

Although Australian and international studies have identified substantial potential gains from further liberalisation of agricultural trade, the full benefits are unlikely to be realised for some time. In the face of pressures from newly emerging suppliers and farmers' declining terms of trade, productivity improvements remain crucial in maintaining the viability of the sector.

Agriculture's workforce

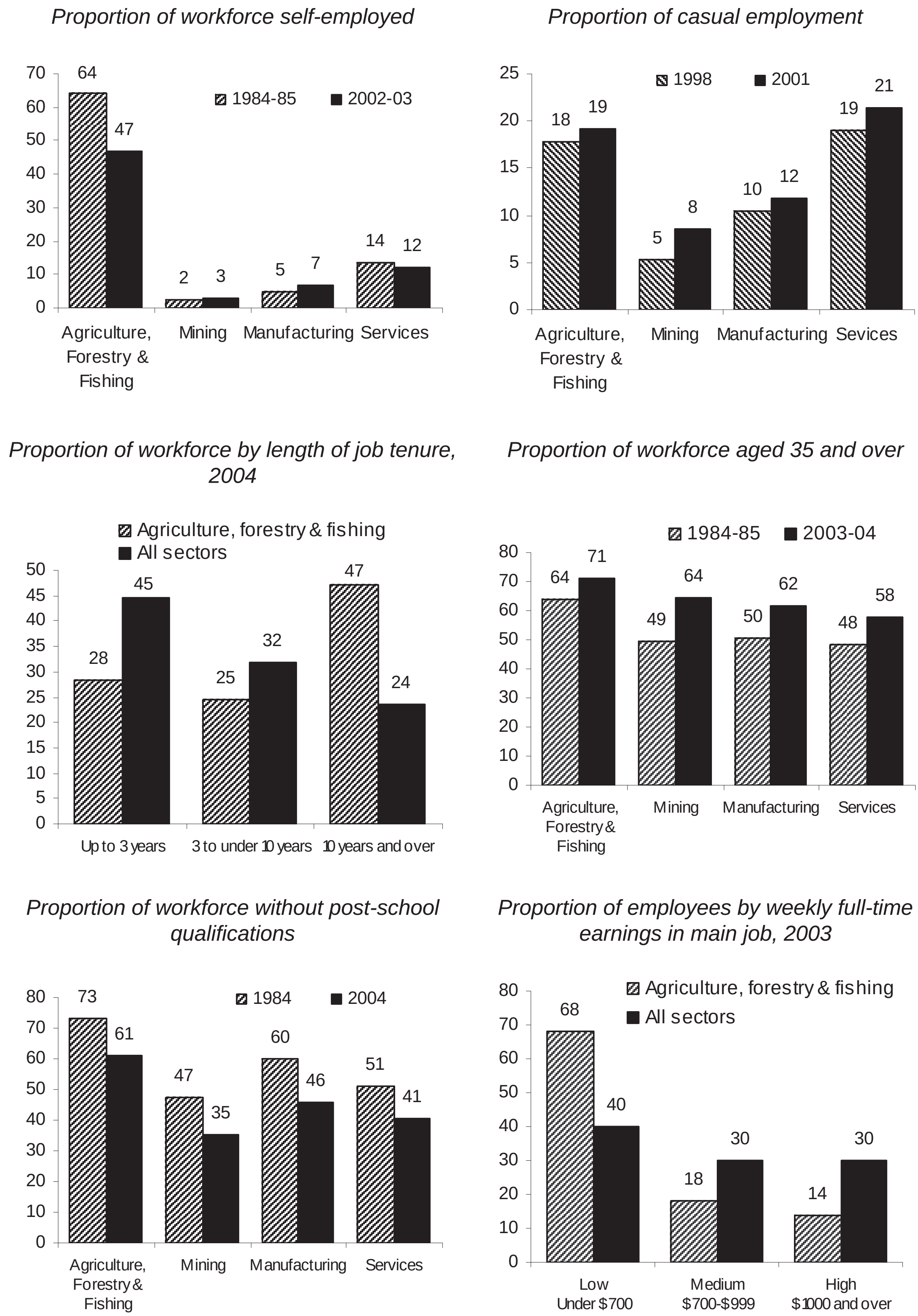
While in absolute terms employment in agriculture has remained relatively stable over the last four decades, there have been changes in the structure of agriculture's workforce. Industries gaining employment share over the last two decades included horticulture and fruit growing, services to agriculture, poultry farming and commercial fishing. Industries losing employment share included grains, sheep and beef cattle farming, dairy, other livestock farming and forestry and logging.

Agriculture's workforce has a number of distinctive features (figure 15). Compared with other sectors of the economy, agriculture has:

- a high proportion of self-employed, family and casual workers;
- long job tenure. Almost half of agriculture's workers have been in their current job for 10 years or more;
- a relatively old workforce. Just over 70 per cent of agriculture's workers were aged 35 years or older in 2003-04; this compares with around 58 per cent for the rest of the economy;
- a low incidence of post-school qualifications. The proportion of the agriculture workforce without post-school qualifications is around 20 percentage points higher than for the workforce generally, while for university training it is more than three times lower than that for the workforce in general; and
- low employee wages. In 2003, median weekly earnings for full-time paid employees in agriculture were around one third lower than those for all full-time employees, making agriculture workers the lowest paid workers in the economy on average.

Many of these features arise from the continuing dominance of family operated businesses in this sector — 99 per cent of Australian farms are family owned and operated. This has provided flexibility in the use of labour in terms of hours worked and engagement in off-farm work.

Figure 15 **Distinguishing features of agriculture's workforce**



The last twenty years, however, have seen a decline in the proportion of employers, own account workers and contributing family workers employed in agriculture, and an increase in the proportion of employees. This can be partly explained by 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 need for hired labour.

An old and ageing workforce

Not only is the agriculture workforce older than the workforce in general, but the average age of farmers has increased significantly over the last two decades — from 44 in 1981 to 50 years in 2001. Factors contributing to this trend include:

- fewer young people entering farming; and
- low exit rates at traditional retirement age, possibly compounded by the limited interest of young people in taking over the family farm.

There are, however, different age profiles among agriculture industries. The horticulture and dairy industries stand out as having younger age profiles, while the beef and sheep industries have the oldest workforces.

Low employee earnings, but farm family incomes broadly comparable

While real earnings per employee for agriculture are low relative to other sectors, these data only relate to full-time employees and as such exclude around half of the agricultural workforce (own account workers, employers and family labour).

The distribution of incomes in agriculture on a family income basis more closely resembles that in the rest of the economy. 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.

Growing importance of off-farm income

Off-farm employment has become increasingly important to maintaining family farm incomes. While the relative importance of farm income to household income varies between years (reflecting seasonal conditions), off-farm income has, on average, accounted for around 65 per cent of all household income on broadacre farms since 1989-90.

Over the period 1989-90 to 2002-03:

- the proportion of farm families deriving a share of their income from off-farm wages and salaries increased from 30 to 45 per cent; and
- average broadacre farm incomes earned from off-farm wages and salaries more than doubled in real terms — from $15 000 to around $33 500 per year.

The increasing importance of off-farm employment reflects, in part, the increased participation of women in the workforce, as well as the increasing incidence of multiple job-holdings by farmers.

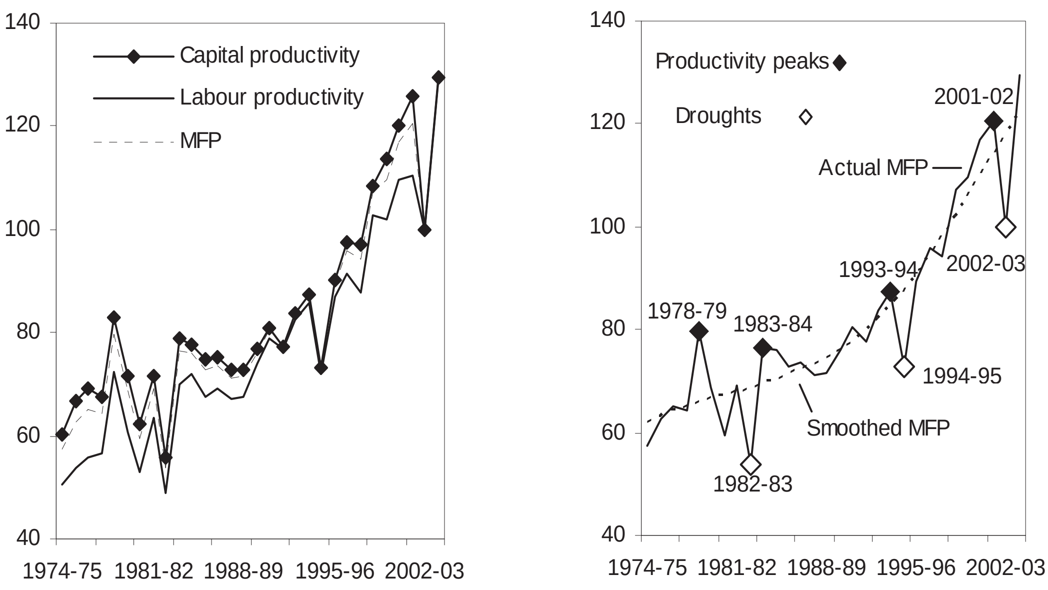
Agriculture's productivity performance

Agriculture's productivity, while quite volatile because of seasonal variations, has exhibited strong growth over the longer-term (figure 16). Multifactor productivity (MFP) growth averaged almost 3 per cent a year over the period 1974-75 to 2003-04 (or 2.3 per cent in trend terms). This was considerably stronger than that achieved in Australia's market sector (1 per cent in trend terms).

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 16).

Figure 16 **Labour, capital and multifactor productivity in the agriculture sector, 1974-75 to 2003-04**

Index 2001-02 = 100



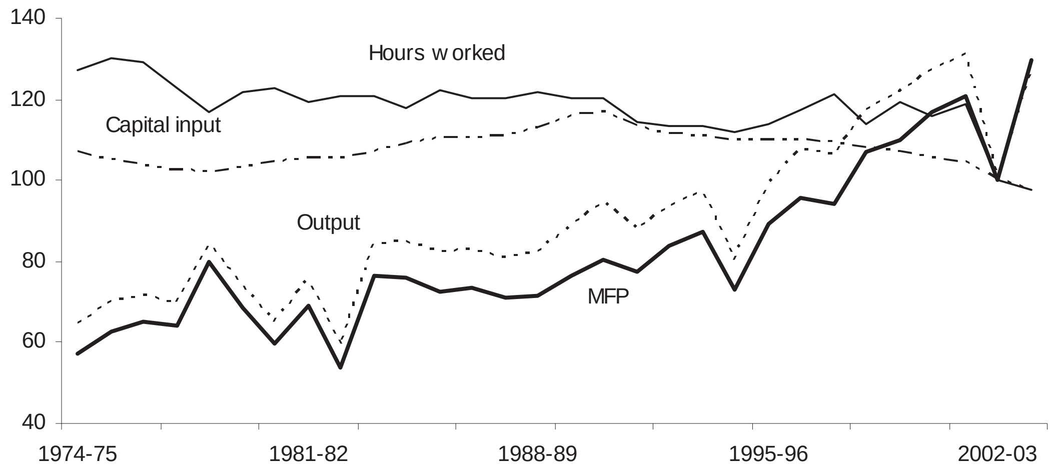
MFP growth in the agriculture sector has also been stronger over the last fourteen years than in the 1970s and 1980s. In trend terms, MFP increased at an annual average rate of 1.3 per cent between 1974-75 and 1989-90. This compares with 3.7 per cent per year between 1989-90 and 2003-04.

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

Productivity — the driver of output growth in agriculture

Productivity growth has accounted for the entire increase in output of the agriculture sector over the last thirty years. Over the period 1974-75 to 2003-04, the quantities of both labour and capital inputs used in agriculture declined, while total agriculture output increased at an annual average rate of around 2.4 per cent (figure 17).

Figure 17 **Growth in inputs, outputs and multifactor productivity for agriculture, 1974-75 to 2003-04**
Index 2002-03



By comparing the actual growth in 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 estimate an agricultural productivity 'dividend'. Applying the trend MFP growth rate of 2.3 per cent, the cumulative annual difference in value added over the period (in constant 2002-03 prices) generated a ‘dividend’ of just over $170 billion over the period.

Productivity trends within agriculture

Productivity growth is far from uniform within the agriculture sector. Over the last three decades, the highest productivity gains in broadacre agriculture have been achieved by the cropping industry (3.3 per cent a year over the period 1977-78 to 2001-02). Mixed crops/livestock farms recorded the next highest growth of 2.5 per cent per year followed by beef and dairy farms with growth rates of 1.8 and 1.7 respectively. Productivity growth in the sheep and sheep-beef industry has been rather modest and insufficient, on average, to offset the deteriorating terms of trade for this industry.

Productivity growth has been closely related to farm size in the broadacre industries, with larger farms typically outperforming smaller farms. For example, in the beef industry over the period 1977-78 to 2001-02, the largest third of beef farms enjoyed strong productivity growth (2.2 per cent a year), while the smaller two-thirds recorded little or no growth. Similarly, large producers of prime lamb recorded growth of 1.4 per cent compared with 0.8 per cent for small producers.

The lumpy nature of many new technologies, such as advanced mechanical harvesters and automated feeding systems, means that they are often better suited to larger scale farming. Also, larger farms are often better placed to finance the use of new management and farming practices.

Drivers of productivity growth in agriculture

A key source of productivity growth in agriculture has been the generation and adoption of new knowledge or technologies. Some examples include:

- the development of more sophisticated farm machinery and equipment;
- the development of improved herbicides, fertilisers and other chemicals that have enhanced yields; and
- genetic modification involving the manipulation of the genetic structure of living organisms (more directly than through conventional plant and animal breeding), which has created opportunities for raising the productive potential of plants or animals by, for example, enhancing their resilience to disease.

Productivity growth has also come about as farmers have made better use of available technologies and management practices. 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).

In addition, productivity growth within the agriculture sector has been shaped by structural changes such as increases in farm size, shifts in the industry mix of the sector and the exit of lower performing farmers.

International comparisons

International data suggest that, in terms of MFP growth, Australian agriculture has performed relatively strongly compared with most other OECD countries over the last two decades — recording a growth rate similar to the United States, but lower than Canada and Denmark.

That said, as noted, there is considerable variation in farm productivity within Australian agriculture. 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 and use of best practice management and technologies. The latter 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.

1 Introduction

Agriculture has historically played an important role in the Australian economy. In the first half of the 20th century, agriculture accounted for around a quarter of the economy's output. And, in the 1950's, its importance as a source of export revenue was such that the Australian economy was commonly described as 'riding on the sheep's back'.

The last few decades, however, have seen considerable changes to the agriculture sector and its contribution to the Australian economy. Agriculture now accounts for less than 5 per cent of the economy's output and for less than a quarter of Australia's total exports. Changes are also evident in terms of the number and size of Australian farms, the composition of the sector's output and the production and marketing strategies employed by farmers.

Some key factors driving change in the sector include globalisation, trade liberalisation, changing consumer tastes, technological advances and innovation and environmental constraints. The unrelenting decline in farmers' terms of trade (that is, the ratio of prices received to prices paid) has also been an important source of pressure for change.

1.1 Objectives of the study

The main objective of this study is to contribute to a better understanding of Australia's agriculture sector and the role that it plays in the economy by identifying and analysing key trends in the sector over the last 20 years or so. The study looks at:

- the changing role of agriculture in the economy (in terms of output, employment and trade);
- the sector's links with other sectors of the economy and how these have changed;
- changes within the sector in terms of activity mix, farm businesses, trade and employment; and

- similarities and differences between the productivity performance of the agriculture sector and other Australian sectors, as well as with agriculture in other OECD countries.

While the focus is on key changes over the last 20 years, the study sometimes uses longer periods to provide a historical perspective or place developments in a broader context.

Given the complexity and breath of issues affecting the agriculture sector, the study does not attempt to cover all issues, but rather focuses on key changes.

Important reasons for studying trends in agriculture

There are a number of important reasons for examining trends in the agriculture sector over the past few decades.

- Because agriculture is a diverse sector, aggregate data tends to hide important changes that are occurring at a more disaggregated level. For example, while the importance of the sector as a whole has declined over time, some commodities, such as grapes and cotton have experienced rapid output growth and thereby captured an increasing share of agricultural output and trade. A study of this nature provides the opportunity to better appreciate the diverse nature of the sector and to gain a better understanding of the significant changes that have occurred within the sector.
- While extensive research has been undertaken on Australia's agriculture sector, particularly for specific commodities and industries, there does not appear to be a trend study of this nature.
- The Commission has previously undertaken studies of trends in Australia's manufacturing (Clark et al. 1996 and PC 2003) and service sectors (McLachlan et al. 2002) This study adds to the set.

1.2 Agriculture — what does it cover?

The term 'agriculture' is used broadly in this report and describes the activities making up the *Agriculture, Forestry and Fishing* division of the Australian and New Zealand Standard Industrial Classification (ANZSIC). The activities under this division include:

> Agriculture — the breeding, keeping or cultivation of all kinds of animal or vegetable life. Forestry — afforestation, harvesting and gathering of forest products. Fishing — the catching, gathering, breeding and cultivation of marine life from ocean, coastal and inland waters. Hunting — the catching or taking of all types of animal wildlife on land (ABS 1993, ANZSIC, Cat. no. 1292.0).

This broad definition has been adopted partly for completeness (in view of the strong affinity between the industries within the division), but also because some of the ABS data covering ‘agriculture’ is only available at this divisional level. That said, with forestry, fishing and hunting accounting for less than 5 per cent of the sector’s output, the focus of the study is on what is traditionally known as ‘agriculture’.

… but there is blurring of the boundaries

The boundaries between what is included under ‘agriculture’ and what is included under other sectors of the economy are blurred. For example, while the growing and sun-drying of grapes is included as agriculture, the preserving of grapes and the production of wine are included as part of the manufacturing sector. Similarly, while cattle feedlot operations are classified as agriculture, the slaughter and freezing of carcases is classified as manufacturing. Food processing activities, such as the canning of fruit and vegetables, are also categorised as manufacturing. A key factor influencing the sector in which activities are placed is the degree of transformation of raw or semi-processed materials (ABS 1993).

There is a similar blurring of the boundaries between some agriculture and service industries. Services to agriculture such as aerial crop spraying, shearing and cotton ginning, for example, are grouped within ‘agriculture’ while activities such as bulk wool classing and veterinary services are included as part of the service sector.

‘Grey’ areas on the boundaries of sectors are not unique to the ANZSIC — similar difficulties arise with other classifications (for example, commodity and trade classification systems), both in Australia and overseas. As such, they do not materially detract from the merits of the ANZSIC framework for describing and analysing variations in the performance of different sectors. For a discussion of the blurring of boundaries between the manufacturing sector and other sectors of the Australian economy (see PC 2003, pp. 3–4).

1.3 Agricultural production systems

The agriculture sector is characterised by a wide range of different production systems with varying input usage. The spatial distribution of these systems is heavily influenced by physical aspects of the operating environment of Australian farms, namely — climatic conditions, water availability, soil and topographical conditions and proximity to markets.

Farms raising beef cattle and sheep, for example, generally use relatively extensive production techniques — so called dryland farming practices — involving a large input of land relative to other inputs. Other activities, such as horticulture, rice and cotton growing are typically smaller in scale and involve a higher use of non-land inputs such as water and labour.

Poultry and pig farming, on the other hand, represent much more intensive forms of production where non-land inputs tend to be dominant and production processes display more in common with processing activities in manufacturing. In such industries, farmers essentially provide 'sheds' to processors who supply the main inputs into the production process (including, for example, poultry/pigs, feed and medications).

Agricultural activities, because they generally have a larger environmental component, are different to production systems elsewhere in the economy. Many of these physical and biological factors, such as variations in rainfall and the onset of disease, are largely outside the control of farmers, yet they can have a significant effect on the level of production, input use, prices and the performance of farms. The 2002-03 drought, for example, saw agricultural output decline by around a quarter and real agricultural income fall by over 50 per cent (Lu and Hedley 2004, pp. 26-27). Reflecting such influences, the National Farmers Federation (NFF) has observed that around 80 per cent of farm profit in Australia is made in around 30 per cent of years (Corish 2004, p. 7).

Because most agricultural production systems rely heavily on the condition and productivity of the natural resource base, the management practices of farmers (including soil, fodder and water management) can exert an important influence on the sustainability of Australia's natural resource base. As the NFF President recently said:

> With Australian farmers responsible for the management of over 62 per cent of the Australian landscape and over 80 per cent of our water resources, farmers are central players in natural resource management (Corish 2004, p. 9).

A number of studies have also demonstrated that policies that encourage sustainable farm and environmental management practices are likely to be important for the future performance of the agricultural sector (see, for example, PC 2004b).

1.4 Structure of the report

In outlining key developments and trends occurring in the agriculture sector over the past 20 years, the report is divided into six chapters.

Chapter 2 examines the role of agriculture in the Australian economy. It looks at agriculture's contribution to output, employment, trade and investment and examines the sector's linkages with other parts of the economy. The changing role of the agriculture sector over the past few decades is also discussed.

Chapter 3 explores key trends within the agriculture sector and the underlying drivers of the changes occurring within the sector.

Chapter 4 looks at key trends in Australia's agricultural trade over recent decades and comments on some of the factors affecting patterns of trade.

Chapter 5 takes a look at jobs in the agriculture sector, highlighting differences with other sectors of the economy. The extent to which jobs in the sector have changed over time and the factors influencing such changes are also discussed.

Chapter 6 examines the productivity performance of agriculture over time compared with other sectors of the economy, as well as productivity trends within the sector. The chapter also compares the productivity experience of Australia's agricultural sector with those of other advanced OECD countries.

2 Role of agriculture in the economy

Key points

- Agriculture plays a small but important role in the Australian economy. In 2003-04, it accounted for less than 5 per cent of the nation's output and employment.
- The sector plays a much bigger role in Australia's exports, accounting for over one-fifth of total goods and services exports in 2003-04.
- The economic contribution of the agriculture sector varies across the States and Territories — its share of output is considerably higher in South Australia, Tasmania, Western Australia and Queensland than it is in New South Wales or Victoria.
- Agriculture plays a significant role in regional Australia. In 2001, almost four-fifths of all agricultural employment was in non-metropolitan regions. Agriculture accounted for more than 25 per cent of total employment in 207 of Australia's 425 labour market regions.
- Agriculture is highly integrated with the rest of the economy, drawing on inputs from the manufacturing and service sectors as well as from imports.
- While agriculture accounts for a relatively small proportion of the economy, variations in the sector's output can have significant flow-on effects for the economy. The 2002-03 drought, for example, saw agricultural output decline by around one-quarter reducing Australia's GDP and employment growth by around 1 percentage point.
- Between the early 1960s and early 1980s, agriculture's share of GDP fell from 14 to around 6 per cent. However, over the past two decades agriculture's share has been relatively stable at 4–6 per cent of GDP. That said, in real terms, the value of agricultural output increased two and a half times over the four decades to 2003-04.
- Agriculture's share of total employment has also fallen, albeit at a slower rate — from 9 per cent in 1966-67 to 4 per cent in 2003-04.
- The relative decline of agriculture reflects improved productivity and falling relative prices for food, coupled with stronger consumer demand for services as incomes rise. As such, the diminishing share of agriculture largely reflects positive or success-related factors and is not a sign of systemic weakness.
- Australia's experience is also consistent with that of other developed countries — there is a strong inverse relationship between national per-capita income and the GDP-share accounted for by agriculture — although the sector's share of output in Australia remains one of the highest in the OECD.

This chapter looks at the role that agriculture plays in the Australian economy. In addition to canvassing the direct contribution of agriculture to output, employment, trade and investment, the chapter examines linkages between agriculture and the rest of the economy. Key trends in the agriculture sector are examined with a focus on the sector's changing role in recent decades. Some of the reasons for the decline in the relative importance of the sector are explored, as is the question of how Australia's experience compares with other countries.

2.1 The contribution of the agriculture sector

Agriculture's contribution to the economy can be measured in a number of ways (figure 2.1). In 2003-04, the agriculture sector:

- contributed 4 per cent, or $25 billion, of the total output of the economy (industry gross value added);
- employed just under 4 per cent of the workforce, or 375 000 people;
- accounted for around 6 per cent of Australia's investment spending and employed 5 per cent of Australia's net stock of capital[1]; and
- represented around 22 per cent of Australia's total exports[2] (merchandise exports plus overseas income from services).

Whilst agriculture's output, employment and investment shares are broadly comparable, its share of exports is considerably greater, being more than five times greater than its output share (figure 2.1).

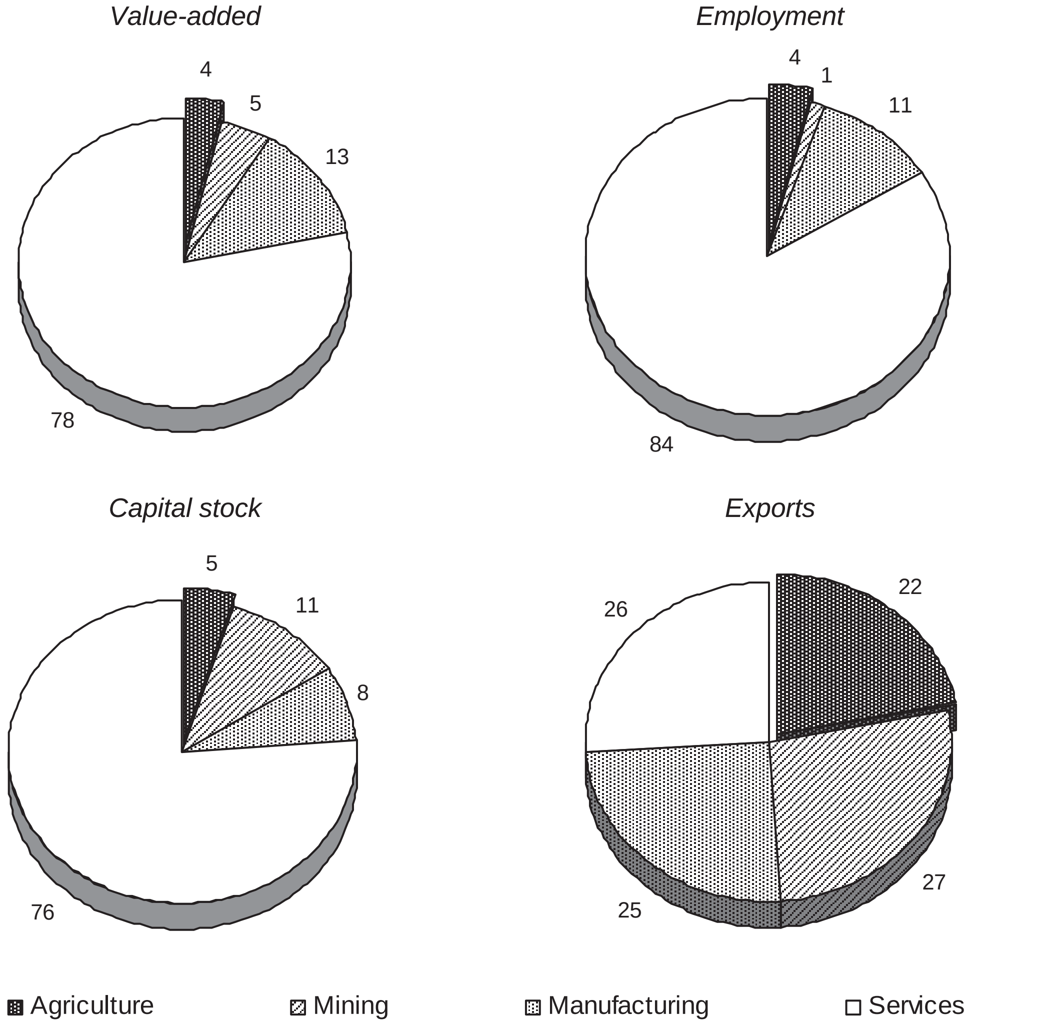
Agriculture firms employ large quantities of capital equipment. In 2003-04, agriculture firms invested $8.0 billion — $4.5 billion on machinery and equipment and the remainder predominantly on livestock, buildings and other structures. With its heavy reliance on machinery and equipment, the sector's investment profile differs from most industries in the Australian economy where the bulk of investment is in buildings and structures.

1 This refers to the depreciated value of Australia's private and public stock of capital and includes all buildings, structures, machinery and equipment for all ANZSIC industries, excluding ownership of dwellings (ABS Cat. no. 5204.0).

2 TREC/SITC basis (see chapter 4).

Figure 2.1 **Agriculture's[a] contribution to Australian economic activity, 2003-04[b]**

Per cent



a 'Agriculture' covers the activities making up the Agriculture, forestry and fishing division of the ANZSIC. **b** 'Ownership' of dwellings is omitted to allow value added shares to sum to 100.

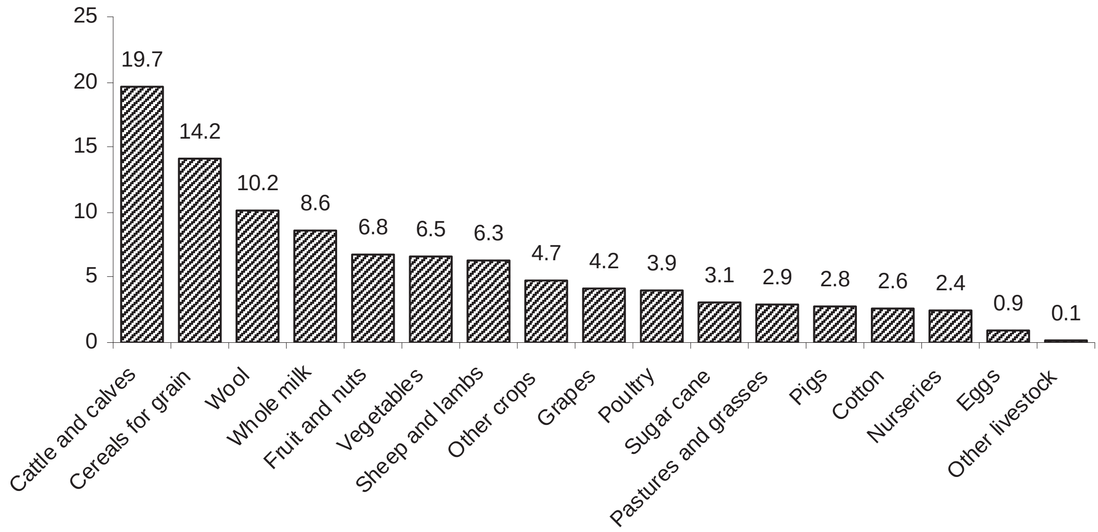
Data sources: ABS (Cat. nos. 6204.0 5, 6203.0 and 5302.0).

In terms of gross value of output, in 2002-03[3], Australia's largest agriculture industries were beef cattle and calves (20 per cent of total agriculture output), cereals for grain (14 per cent), wool (10 per cent) and milk (9 per cent). Other large industries included fruit and nuts, vegetables, sheep and lambs, and grapes (figure 2.2).

3 Latest available detailed ABS industry data (ABS Cat. no. 7503.0).

Figure 2.2 **Industry contributions to agriculture[a] output, 2002-03**

Per cent



a No consistent data are available on the output of the forestry and fishing industries. However, the industries included comprise the overwhelming majority of the output of the Agriculture, forestry and fishing division of the ANZSIC — combined, these industries have, on average, accounted for 94 per cent of the agriculture sector's value-added since 1974-75.

Data source: ABS (Cat. no. 7503.0).

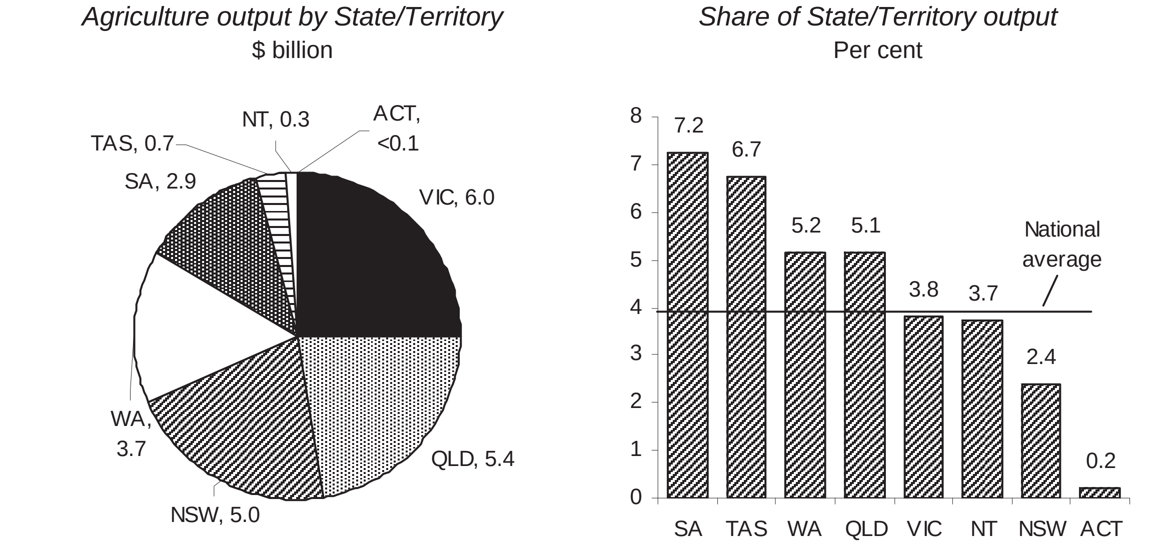
In terms of farm numbers, beef cattle farming was also the major agricultural activity, accounting for 25 per cent of all farms in 2002-03. Grain growing and mixed farming (grain-sheep/beef cattle) were the next largest, both accounting for around 12 per cent of Australian farms.

Agriculture in the States and Territories

About 25 per cent of agriculture output is produced in Victoria and just over 20 per cent in each of Queensland and New South Wales. The Northern Territory and the Australian Capital Territory combined account for just over 1 per cent of total agriculture output (figure 2.3).

The relative economic importance of the agriculture sector varies significantly across Australian States and Territories. Agriculture's share of State output is stronger in South Australia (7.2 per cent), Tasmania (6.7 per cent), Western Australia (5.2 per cent) and Queensland (5.1 per cent), than the larger States (Victoria and New South Wales). Its importance to the Northern Territory (3.7 per cent of output) is slightly below the national average of 3.9 per cent, and it plays a negligible role in the Australian Capital Territory (figure 2.3).

Figure 2.3 **Agriculture output[a] in the States and Territories, 2003-04**



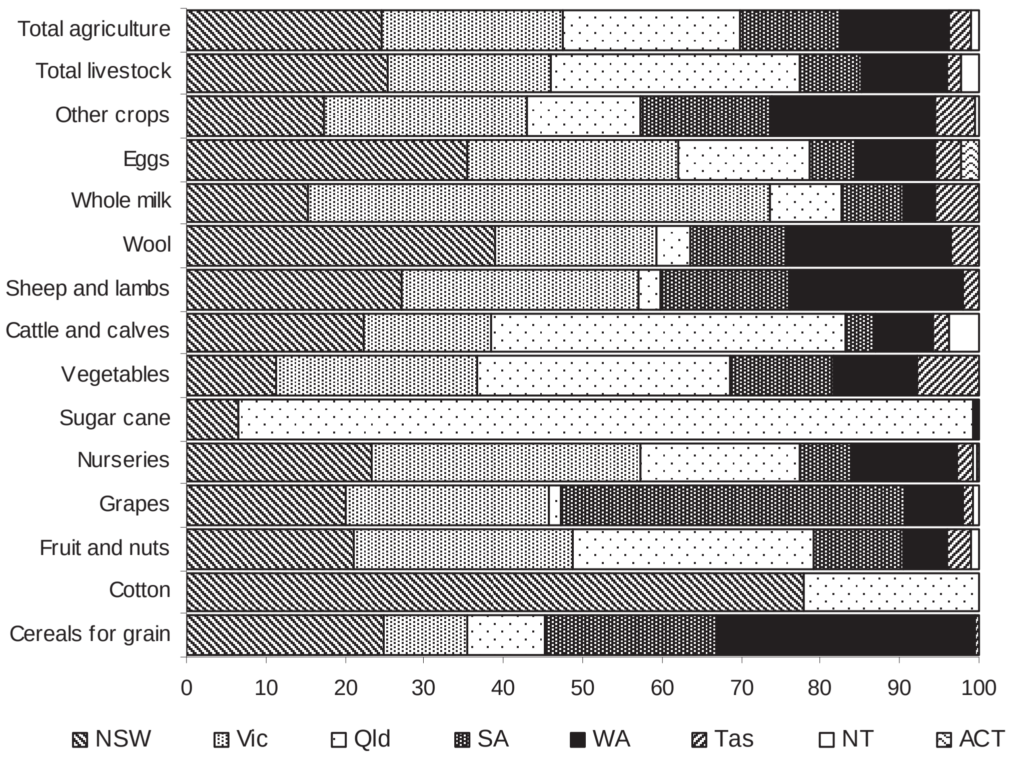
[a] The data are based on current price factor income measures of output derived from State National Accounts. This is close, but not identical to, direct measures of value added. Total production excludes general government and ownership of dwellings, so the measures shown here are different from GDP shares. In 2003-04, total factor income for the agriculture sector was $24.0 billion compared with $24.8 billion in value-added.

Data source: ABS (Australian National Accounts: State Accounts 2002-03, Cat. no. 5220.0).

An examination of the relative contributions of different agriculture industries to agricultural output in the different States and Territories reveals that (figure 2.4):

- almost 60 per cent of Australia's milk is produced in Victoria;
- almost half (45 per cent) of Australia's beef cattle and over 90 per cent of all sugar is produced in Queensland;
- South Australia produces 44 per cent of the nation's grapes and 22 per cent of its cereal grains;
- around 80 per cent of the nation's cotton production, 40 per cent of wool production and over one-third of all egg production is in New South Wales;
- Western Australia produces almost one-third of Australia's cereal crops and over one-fifth of sheep, lamb and wool production;
- Tasmania contributes a disproportionately large share of total vegetables and milk output; and
- The Northern Territory specialises in cattle production, with a small but significant production of fruit and nuts.

Figure 2.4 **Agricultural output shares[a] by State and Territory, 2002-03**
Per cent



[a] Based on gross value of production data for 2002-03 (current prices, latest available data).

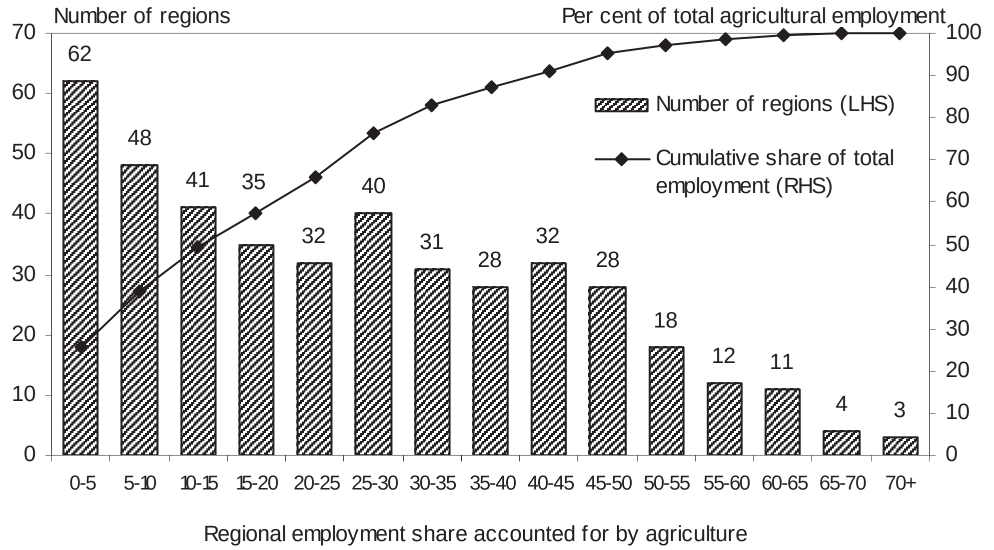
Data source: ABS (Cat. no. 7503.0).

The importance of agriculture to regional Australia

Agriculture plays an important role in regional Australia. In 2001, almost four-fifths of all agricultural employment was in non-metropolitan regions. Agriculture directly accounted for more than 25 per cent of total employment in 207 of Australia's 425 labour market regions.

Employment shares for agriculture differed markedly across regions, with shares ranging from zero to over 70 per cent (figure 2.5). As expected, agriculture's employment share was highest in the smaller regions. For example, 49 per cent of agricultural employment was distributed among 151 regions with agricultural employment shares of less than 10 per cent. These regions had a median employment level, for all sectors, of just under 7000 persons. The remaining 51 per cent of agricultural employment was distributed among 274 regions with agricultural employment shares ranging from 10 to over 70 per cent. The median employment level, for all sectors, for these regions was under 1500 persons.

Figure 2.5 **Distribution of regions by share of employment in agriculture and by contribution to total agricultural employment[a], 2001**



[a] Data are based on BTRE data which divides Australia into 425 regions — 8 capital cities, 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.

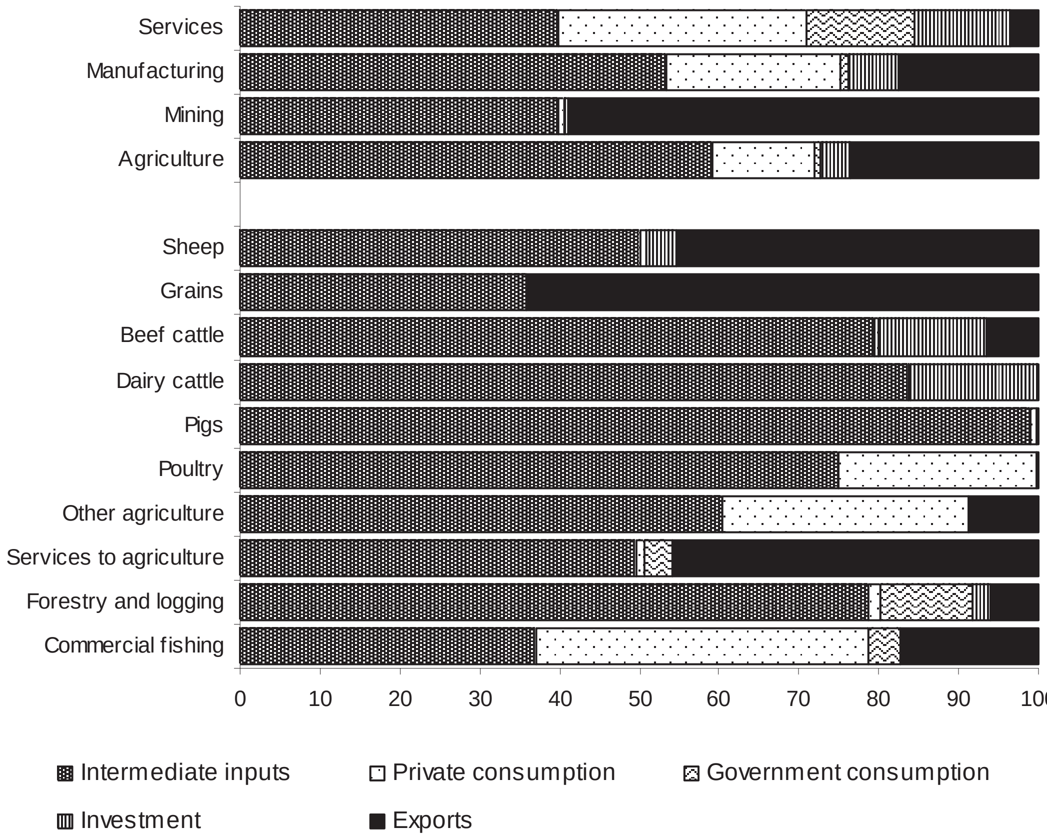
Data source: BTRE (2004) Industry Structure Database.

Linkages to other sectors

The measures presented above do not fully capture the role of agriculture in the economy because they fail to take into account the strong linkages between sectors. Input-output tables reveal these interdependencies. For example, analysis of these tables reveals that the agriculture sector provides the highest proportion of its output as intermediate input for use in other sectors. In 1998-99, around 60 per cent of the total value of agricultural output was used as intermediate inputs in either the goods or service sectors — for example, in processed foods and restaurant meals (figure 2.6).

Around one-quarter of the agriculture sector's output was exported directly — making it the most export-oriented sector after mining. There was considerable diversity with grains, sheep/wool and services to agriculture directly exporting the highest proportion of their output. The pigs, dairy and beef cattle industries provide the highest proportion of their output to other Australian industries (predominantly for processing or packaging in the manufacturing sector). The industries with the highest proportions of direct sales to final consumers (households) are commercial fishing, other agriculture (including fruit and nuts and vegetables) and poultry (see appendix A).

Figure 2.6 **Distribution of output by demand category[a], 1998-99**
Per cent



[a] Data are based on input-output industries and exclude changes in inventories.
Source: ABS (Cat. no. 5209.0).

Input-output data presented in table 2.1 show inputs as a proportion of output for the various agriculture industry groupings and illustrate the high degree of interdependence between agriculture and other industries.

Reading *across* the first row we see that, to produce $100 of output in 1998-99, firms in the agriculture sector required, on average, $42.10 worth of intermediate inputs, of which services accounted for $19.40. The most important service industries to the agriculture sector are: wholesale trade ($2.90 worth of intermediate inputs); transport and storage ($3.70 of inputs, with road transport being particularly important to the beef, dairy and grains industries); and banking, finance and business services ($3.80 of inputs).

Electricity and water supply are important intermediate inputs for some agriculture industries, accounting for around 3 per cent of the combined output of the dairy cattle and poultry industries. Communications also account for around 1 per cent of output for most agricultural industries.

Table 2.1 **Direct requirements coefficients[a], by sector, 1998-99**

Per cent

		These sectors provide inputs ...							
		Ag	*Mining*	*Mfg*	*Services*	*Total intermed. inputs*	*Value-added*	*Imports*	*Total*
... to the output of these sectors	Agriculture	**11.1**	**0.1**	**11.4**	**19.4**	**42.1**	**49.6**	**5.9**	**100.0**
	Mining	**0.1**	9.2	8.0	22.7	40.0	53.2	5.4	100.0
	Services	**0.3**	0.6	7.8	31.0	39.8	54.3	4.1	100.0
	Manufacturing	**6.5**	3.7	21.7	21.2	53.3	31.1	14.7	100.0
	Processed food	***26.5***	*0.6*	*20.4*	*20.9*	*68.4*	*26.5*	*4.3*	*100.0*
	Meat and dairy products	***41.2***	*0.1*	*13.9*	*19.7*	*74.9*	*21.9*	*2.5*	*100.0*
	Beverages	***15.6***	*0.2*	*20.0*	*25.6*	*61.6*	*32.4*	*2.7*	*100.0*
	Tobacco products	***3.5***	*0.1*	*5.5*	*31.8*	*41.2*	*43.3*	*15.0*	*100.0*
	Textiles, clothing and footwear	***9.7***	*0.4*	*23.3*	*19.1*	*52.6*	*28.8*	*15.7*	*100.0*
	Wood and paper products	***4.7***	*0.6*	*20.8*	*27.4*	*53.7*	*30.1*	*15.3*	*100.0*

[a] Based on direct allocation of competing imports. This means that all flows recorded in the first four columns of figures refer only to the use of domestic inputs and do not reflect the technological input structure of the sectors. The individual items do not add to 100 because the input-output column on indirect taxes is not shown.

Source: ABS (*Australian National Accounts: Input-output Tables 1998-99*, Cat. no. 5209.0).

Given the tight margins on many agriculture products arising from high levels of international competition, efficiently provided infrastructure services are important in allowing farmers to contain production costs.

Around one-quarter of all intermediate inputs required by the agriculture sector are sourced from within the sector — mainly from agricultural services and grain producers (who provided substantial inputs such as seed or feed products to most agriculture industries). The remaining inputs are mostly manufactured items, with $100 of output by the agriculture sector drawing on $11.40 worth of manufactured inputs.

Imports account for around $6 of every $100 of output for the agriculture sector. This is above that of the mining ($5.40) and service ($4.10) sectors, but less than half that for manufacturing ($14.70). The agriculture industries with the highest import shares include dairy and commercial fishing. The lowest are grains and poultry.

A recent study undertaken by Econtech (2005) for the Australian Farm Institute and Horticulture Australia sought to quantify the extent of economic activity associated with the agricultural sector — including activity within the sector as well as within industries in other sectors providing goods and services to farmers or using farm produce to manufacture or market product for consumption. The study estimated that 'farm-dependent' industries accounted for around 12 per cent of Australia's GDP (box 2.1). The 'farm-dependent' economy, however, was broadly defined and included, for example, the output and employment of industries such as accommodation, cafes and restaurants, food retailing and textiles, clothing and footwear.

Box 2.1 **Australia's farm dependent economy**

There are a number of different ways in which the direct and indirect role agriculture plays in the economy can be measured. A recent study by Econtech for the Australian Farm Institute and Horticulture Australia concluded that 'farm-dependent' industries account for around 12 per cent of Australia's GDP for the six years up to and including 2003-04. Farm-dependent industries comprised:

- the agriculture sector (3 per cent[4]);
- the farm-input sector (1 per cent) — comprising industries that supply inputs to agriculture such as chemicals (fertilisers), transport, storage, wholesale trade and business services; and
- the farm-output sector (8 per cent) — comprising industries that are deemed to rely on agriculture for a large proportion of their inputs, such as food retailing, accommodation, cafes and restaurants and food and clothing manufacturing.

Estimates of shares of GDP and employment accounted for by the agri-food chain are highly sensitive to assumptions made about what industries are included. For example, the largest component of the farm output sector was the accommodation, cafes and restaurants industry. This industry accounted for 2.6 per cent of GDP and employed over 434 000 people in the comparison year (1998-99), amounting to just under one-third of the farm-output sector. On average, accommodation, cafes and restaurants sourced 17 per cent of their inputs from either the agricultural sector or the food manufacturing industries.

Similar studies have been undertaken for the United Kingdom, the United States and Canada (Department for Environment, Food and Rural Affairs 2004, Agriculture and Agri-Food Canada 2003 and Lipton et al 1998). Although the methodologies and findings of these studies vary considerably, they all suggest that there are strong links between agriculture and other sectors of the economy.

Sources: Econtech (2005), Department for Environment, Food and Rural Affairs (2004), Agriculture and Agri-Food Canada (2003) and Lipton et al. (1998).

4 This is smaller than the measure used throughout this chapter (4 per cent in 2003-04) due largely to the treatment of ownership of dwellings in the PC's estimates of sector shares (see note b to figure 2.1).

An examination of changes in inter-industry linkages between 1980-81 and 1996-97 (the longest consistent series available) reveals that, whilst the proportion of agricultural intermediate inputs supplied to the rest of the economy has declined slightly, agriculture firms have been drawing increasingly heavily on a range of service industries. Over the period, service inputs almost doubled in importance with an increase of around 9 percentage points (table 2.2).

Table 2.2 **Changes in input-output relationships, 1980-81 to 1996-97[a]**
Percentage point changes

		These sectors provide inputs . . .			
		Agriculture	Mining	Manufacturing	Services
… to the output of these sectors	**Agriculture**	**3.3**	**0.0**	**-1.0**	**8.9**
	Mining	**-0.2**	-2.9	-1.3	-1.0
	Manufacturing	**-1.6**	-0.2	-2.2	5.9
	Services	**0.2**	-0.2	-4.6	9.3

a Data are based on the absorption matrix of the ABS input-output tables (with indirect allocation of competing imports so that the table reflects the changing technological input structure of agriculture and other sectors). The original 1996-97 and 1980-81 input-output tables were adjusted to increase their consistency with each other. This involved using a concordance between ANZSIC and ASIC and the use of the earlier SNA68 conventions for the treatment of transport margins. The input-output coefficients for 1980-81 were subtracted from those for 1996-97 to derive the figures reported in the table.

Source: ABS (*Australian National Accounts, Input-Output tables 1980-81 and 1996-87* Cat. no. 5209.0), PC (2003).

In addition, intermediate inputs supplied by agriculture firms to other agriculture firms increased strongly — up 3.3 percentage points. Increases in supply of inputs from the 'Other agriculture'[5] industry contributed almost all (2.9 percentage points) of this growth.

2.2 Trends in agriculture

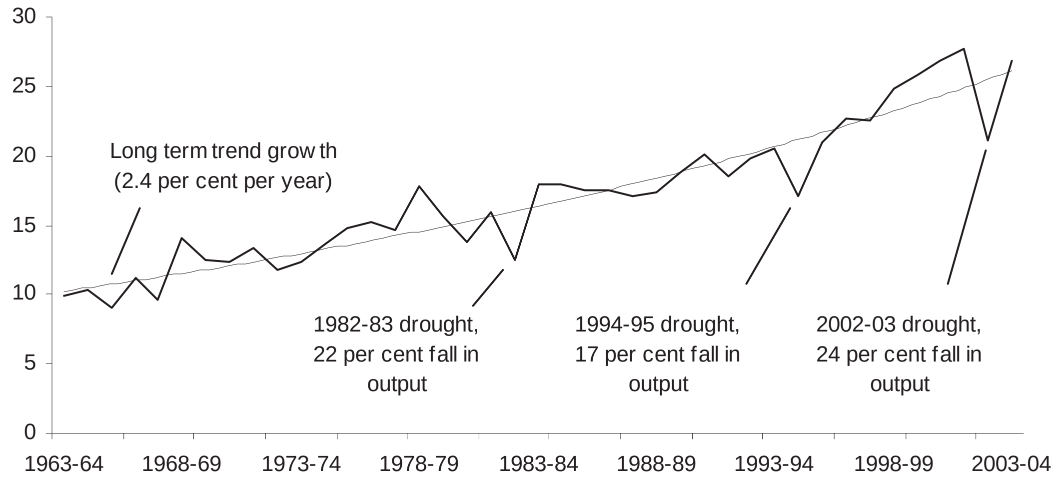
The agriculture sector's output has grown considerably in recent decades, increasing two and a half times in real terms, from around $10 billion in 1963-64 to $27 billion in 2003-04 (constant 2002-03 prices, figure 2.7).

The agriculture sector is characterised by substantial volatility in output over time, with fluctuations in climatic conditions, such as droughts, substantially impacting

5 'Other agriculture' comprises cotton, sugar, grapes, fruit and vegetables, plant nurseries, horse studs and all other crops with the exception of the traditional agricultural commodities of sheep, beef, grains, dairy, pigs and poultry (ABS, *Australian National Accounts: Input-Output Tables (Product Details) 1996–97*, Cat. no. 5215.0).

on output in some years. For example, output declined by around one-fifth in the droughts of the early-eighties and the mid-nineties (figure 2.7). The most recent drought has been the harshest on record, with output declining by almost one-quarter in 2002-03. However, as with previous downturns, output rebounded strongly in 2003-04 to levels slightly above the sector's long-term growth path — which has seen real output growth (in trend terms) of 2.4 per cent a year.

Figure 2.7 **Growth in agriculture output[a], 1963-64 to 2003-04**
Value-added ($ billion, constant 2002-03 prices)



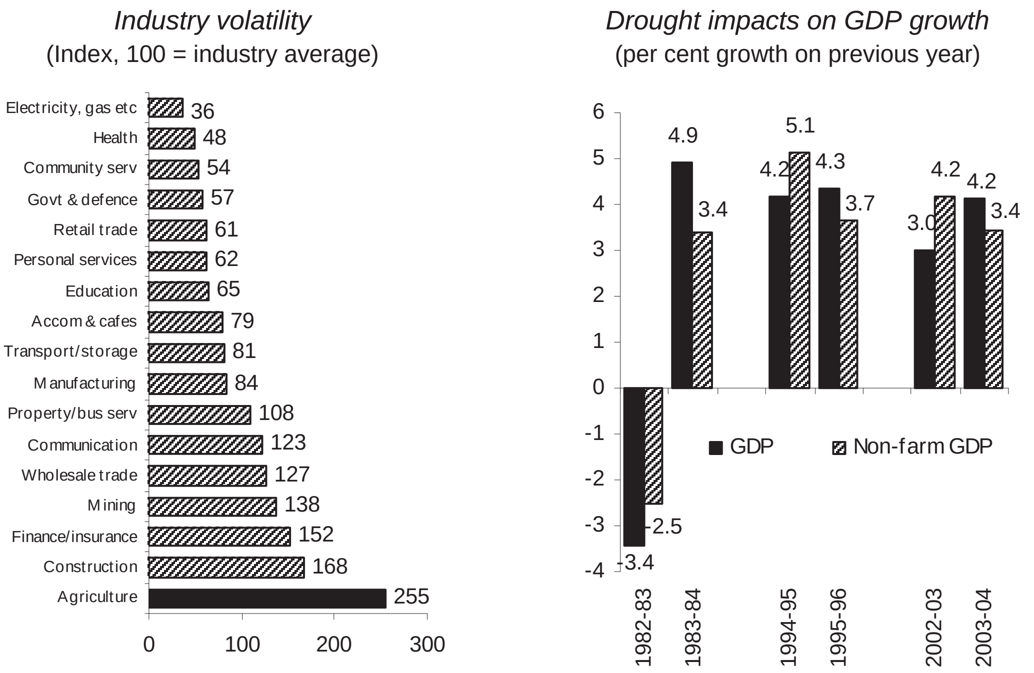
[a] Annual trend growth rates presented here (and throughout this report) are calculated by regressing the log of the relevant variable (in this case value-added) against a constant and a time trend.

Data source: ABS (Cat. no. 5204.0) and RBA (1996).

Over the period 1974-75 to 2003-04, agriculture registered the highest volatility in year-to-year output growth of all ANZSIC industry divisions — with an index of volatility more than two and a half times greater than the average for all industries (figure 2.8). Output volatility in agriculture was also substantially higher than the next most volatile industries (construction, finance and insurance and mining).

Volatility in agriculture output can have a substantial impact on measured growth rates for the economy as a whole, particularly during drought-recovery cycles. A comparison of growth rates for GDP and non-farm GDP reveals that agriculture has shaved around one percentage point off GDP growth during the last three droughts. For example, GDP growth in 2002-03 was 3 per cent compared with non-farm growth of 4.2 per cent. Similarly, rebounding agriculture output in 2003-04 meant that GDP increased by 4.2 per cent, 0.8 percentage points higher than non-farm GDP (figure 2.8).

Figure 2.8 **Industry volatility[a] and GDP growth, 1974-75 to 2003-04**



[a] Industry volatility is calculated by taking the standard deviation of the percentage difference between actual and trend annual output (chain-volume index, 2002-03 prices) for every year from 1974-75 to 2003-04 for all 17 ANZSIC industry divisions. Data are indexed to the industry average and ranked. Trend data are estimated using a Hodrick-Prescott smoothing filter (see appendix D and PC 2003).

Data source: ABS (Cat. no. 5204.0).

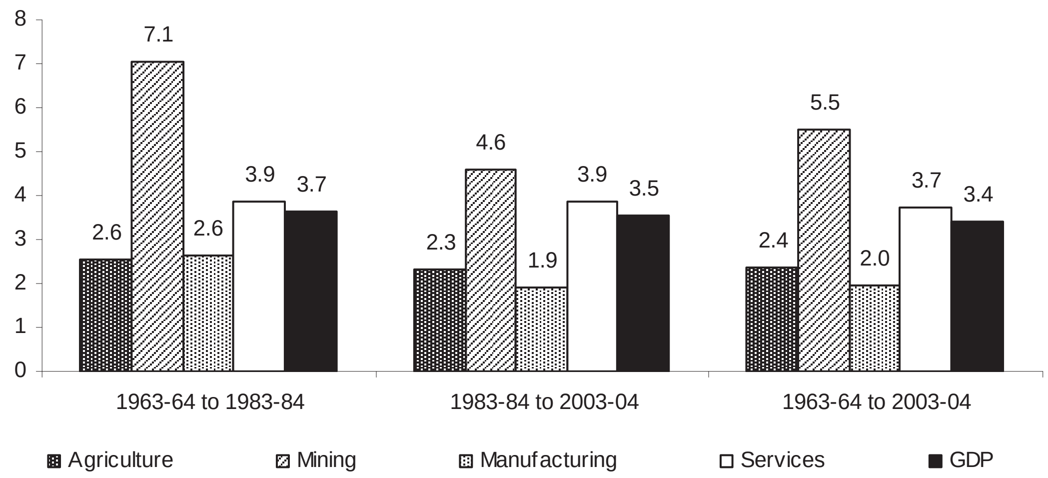
Ongoing drought conditions, in New South Wales and Victoria in particular, have seen agricultural output decline steadily over the past twelve months, with four consecutive declines in quarterly output since the peak in the March quarter 2004. Overall, agricultural output declined 6.7 per cent in the first three quarters of 2004-05 compared with the corresponding period for 2003-04 (constant 2002-03 prices, seasonally adjusted). Although the falls are not as large as those registered in the 2002-03 drought, they indicate that agriculture is having a substantial negative impact on GDP growth in 2004-05. For example, Treasury budget forecasts (produced in May 2005) indicated that farm GDP is expected to fall 8 per cent in 2004-05 as a result of dry conditions in many areas, although farm GDP is expected to increase by 5 per cent in 2005-06 assuming a return to average seasonal conditions (Treasury 2005).

However, more recent ABARE (2005a) crop forecasts suggest that farm GDP growth in 2005-06 could be lower than this, with an expected fall in crop production of around 17 per cent in 2005-06. Strong growth in wheat production in Western Australia is expected to be more than offset by substantial falls for the eastern States, such as in New South Wales — which is expected to fall 55 per cent — and South Australia.

Growth relative to other sectors

While agriculture has continued to grow in absolute terms, faster growth in other sectors (predominantly service industries) has seen the relative importance of agriculture decline steadily. For example, in the two decades to 2003-04 real agriculture output increased in trend terms at 2.3 per cent a year. This was slightly stronger than growth in the manufacturing sector over the period (1.9 per cent per year), but below the 3.5 per cent annual growth recorded for the economy as a whole. The economy-wide result was largely driven by rapid growth in services (3.9 per cent a year) and, to a much lesser extent, by rapid growth in mining output (4.6 per cent a year). Agriculture's growth performance was broadly similar in the two decades to 1983-84, with agriculture recording slower growth than services and mining (figure 2.9).

Figure 2.9 **Sectoral growth rates[a], 1963-64 to 2003-04**
Trend annual average growth (constant 2002-03 prices)

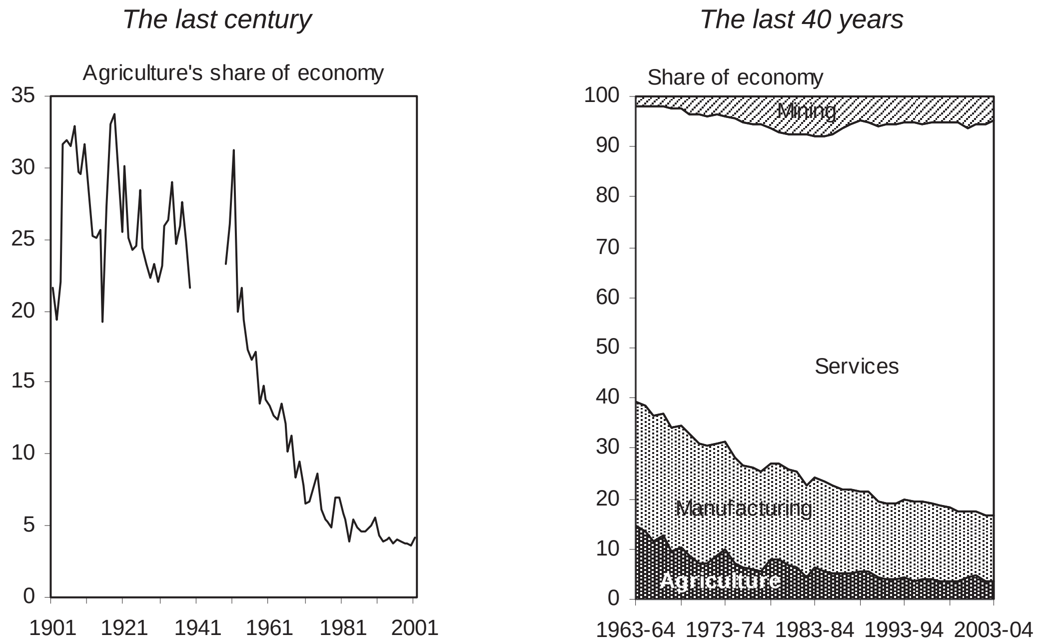


[a] Due to the way trend growth rates are estimated (see note a in figure 2.7), growth estimates for the full period are not directly comparable to the estimates for the two sub-periods. For example, trend growth for GDP for the four decades was 3.4 per cent a year, which was slightly lower than the estimates for each of the two sub-periods (3.7 and 3.5 per cent). An alternative would be to calculate point-to-point annual average growth. But, although these data are additive across time periods, the resulting growth rates can be highly misleading as they are greatly affected by choice of start and end years. Hence, only trend growth estimates are reported here.

Data sources: ABS (Cat. no. 5204.0) and PC (2003).

Due to a combination of slower growth rates and shifts in relative prices (discussed below), agriculture's share of GDP in current prices fell from around 14 to 6 per cent between the early 1960s and the early 1980s. This followed sharp declines in the 1950s, where agriculture's share fell 12 percentage points over the decade — from 26 per cent in 1950 to 14 per cent in 1960. This contrasts with the experience of agriculture in the first half of the 20th century, where its output share oscillated around 25 per cent of GDP (figure 2.10). Over the past two decades, agriculture's shares of GDP and employment have declined at a much slower rate — with shares ranging from 4 to 6 per cent of GDP.

Figure 2.10 **Agriculture's share of GDP[a]**
Per cent, current prices



[a] 1962-63 is the earliest year for which data are available on a comparable basis with recent data. Data from two sources have been spliced to form a continuous serious. ASIC current price industry gross value-added shares are used the period 1963-64 to 1989-90, while shares from 1990-91 are based on ANZSIC current price industry gross value data. Although relative industry shares are affected by choice of splicing year the overall trends are unaffected. Services exclude gross operating surplus from dwellings.

Data sources: ABS (Cat. no. 5204.0), RBA (1996), Butlin (1962), Wonder and Fisher (1990), PC (2003).

Agriculture's employment share has followed a similar trend to its output share. In 1966-67, 443 000 people were employed in the agriculture sector — accounting for around 9 per cent of total employment. Employment in the sector remained relatively stable over the next three and a half decades, with 438 000 people working in the sector in 2001-02. However, as with GDP, agriculture's *share* of total employment fell steadily to around 5 per cent in 2001-02 due to strong employment growth in the service sector. The drought of 2002-03 also had a substantial impact on agricultural employment, with a peak to trough fall in the order of 70 000 jobs. However, unlike output, agricultural employment remains substantially below pre-drought levels (discussed further in chapter 5).

The fall in the agriculture sector's output share of around 20 percentage points since the early 1950s, has meant that agriculture has contributed more to compositional change in the Australian economy over the past half century than the manufacturing sector (which fell from a peak of around 27 per cent in the 1950s to 13 per cent in 2003-04). The significance of this change is accentuated by the fact that the overwhelming majority of agricultural activity is based in regional Australia, where alternative industries and job opportunities are not as readily available as in the cities. In these circumstances, pressure can be placed on adjustment mechanisms as workers and resources seek out alternative opportunities. However, most of the decline in the sectoral output share of agriculture occurred between the 1950s and the 1970s. The substantial and ongoing changes within manufacturing since the early-1980s have seen it take over from agriculture as the major source of structural adjustment in Australia over the past two decades (PC 2003).

Due to the relatively small size of the Australian agriculture sector, substantial changes within the sector now have less impact on the structure of the economy than in previous decades. For example, ABARE (2005b) forecasts suggest that the gross value of farm production will decline at a rate of 1.6 per cent a year in real terms between 2003-04 and 2009-10. Based on current Treasury (Budget 2005) projections[6] for GDP growth over this period, this would translate into a fall in agriculture's GDP share of less than one percentage point.

Comparisons with other countries

The relatively small share of economic activity directly accounted for by agriculture is not unique to Australia. It is a common phenomenon among OECD countries. In 2001, agriculture accounted for less than 5 per cent of GDP for almost all OECD countries — the exceptions being Greece (7 per cent) and New Zealand (6.7 per cent) (figure 2.11).[7]

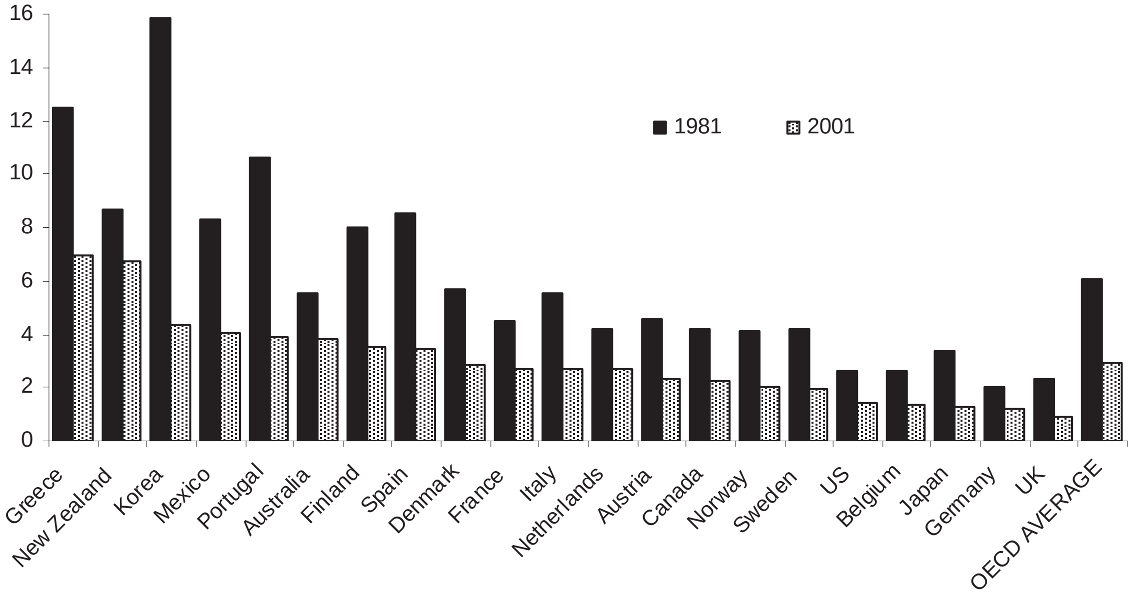
A notable feature of the OECD data is the extent of diversity — with output shares ranging from a high of 7 per cent in Greece to under 1 per cent for the United Kingdom in 2001. Australia's share (3.8 per cent) is above the OECD average, and was nearly three times that of our two largest trading partners, the United States and Japan, with agricultural shares of 1.4 and 1.3 per cent of output respectively.

[6] GDP is forecast to increase 2 per cent in 2004-05 and 3 per cent in 2005-06. It is then projected to increase at 3.5 per cent a year in 2006-07 and 2007-08 and 3.25 per cent in succeeding years (Treasury 2005).

[7] Data refer to the 21 OECD countries for which data are available (excludes the Slovak Republic, Czech Republic, Hungary, Poland and Switzerland).

Figure 2.11 **OECD countries share of output contributed by agriculture, 1981 and 2001**

Per cent, share of gross value added (basic prices)



Data source: OECD Stan Database (2004).

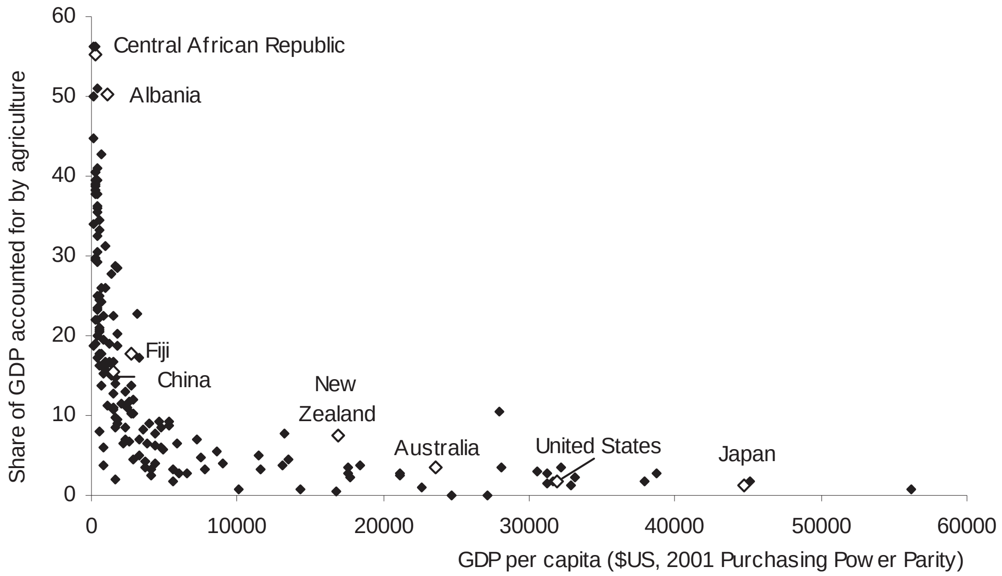
A declining trend in the average output share accounted for by agriculture was evident for the OECD for the period 1981 to 2001, decreasing by 3 percentage points — from 6.1 to 2.9 per cent. All countries for which data are available recorded decreases.

The trends in agricultural employment are similar to that of output. In 2001, agriculture accounted for, on average, 4 per cent of total employment in the OECD. Australia had one of the higher agricultural employment shares at 4.8 per cent.

An examination of a broader set of countries reveals a clear inverse relationship between per capita income levels and the share of the economy accounted for by agriculture (figure 2.12).[8] A similar relationship is evident when shares of employment are examined. Likewise, trend increases in GDP per capita in a given country are inevitably mirrored by a declining share of agriculture in the economy.

8 When log values were taken the following relationship was evident: Ln (agriculture share of GDP) = -0.6409 Ln (per capita GDP) + 7.1869, R^2 = 0.7226, N = 165, t-stat = -20.6, indicating that a 10 per cent rise in GDP per capita is associated with a 6.4 per cent decline in agriculture's share of GDP.

Figure 2.12 **GDP share of agriculture and per capita income, 2000-01**[a]
Per cent



a Where data for 2000-01 were unavailable for some countries (15 of the 165 countries employed), the closest available year was employed as follows: Switzerland, Canada, Nicaragua, Hungary and Kiribati — 1998, New Caledonia and Iceland — 1997, New Zealand — 1996, Kuwait and Brunei — 1995, Cyprus and Saudi Arabia — 1994, United Arab Emirates and Malta — 1993, and Oman — 1992.

Data source: World Bank (World Tables 2004).

This relationship is also evident over time, with all countries exhibiting falls in agriculture's GDP share as their per capita income rises. Also, the largest declines were evident in those developing countries with the fastest overall growth rates in GDP per capita. This well established relationship[9] reflects a number of demand and supply factors, including changes in consumption patterns as incomes rise and productivity improvements. These are discussed below.

2.3 Reasons for the relative decline of agriculture

Three factors are commonly considered to account for the declining relative importance of agriculture. They are:

- shifts in consumer demand away from agricultural products towards services as incomes rise;
- changes in the relative prices of goods and services as economies grow; and
- technological change/innovation and its impact on agricultural productivity.

[9] See, for example, Maddock and McLean 1987, Taylor (2001).

Changing patterns of consumer demand

A common explanation for the steady decline in the relative importance of agriculture in advanced economies is changing consumer demand patterns as incomes rise.

International evidence shows that, as economies develop, the relative proportion of people's income spent on food declines[10] — while the share devoted to manufactures and (more importantly) services, increases. This implies an income elasticity of demand below unity for food and above unity for services. As discussed by McLachlan et al. (2002, pp. 25–7), the international evidence on income elasticities is mixed, although most Australian studies confirm that elasticities for many services exceed one. More recent evidence from abroad also suggests that income effects have been a significant force for structural change in developed economies.

Australian household consumption data confirm that a decreasing proportion of household income is now spent on food and other agriculture-intensive products. In 1963-64, over 23 per cent of the consumption expenditure of the average Australian household went towards food (17 per cent), and alcohol and tobacco (6 per cent) (figure 2.13). By 2003-04, it had fallen substantially (to just over 14 per cent) — with food comprising 10 per cent and tobacco and alcohol 4 per cent. Share declines were also registered for clothing and footwear (from 9 per cent of household expenditure to under 4 per cent). This industry also draws on wool and certain other outputs of the agriculture sector (discussed in section 2.1). These falls reflect the rapid growth in household demand for services. In real terms, household expenditure on services has increased by about 450 per cent over the past four decades, leading to an increase in the share of household income spent on services of around 16 percentage points. In contrast, household spending on food increased by a more modest 160 per cent over the same period.

The broad pattern indicated by the household expenditure data suggests that shifting consumer preferences are likely to have been a key determinant of the relative decline in agriculture output and the growth of services. These trends are also reflected in most of Australia's trading partners. Hence, although the majority of the output of the agriculture sector is sold overseas, the same patterns of consumption have moderated global demand growth for agricultural commodities.

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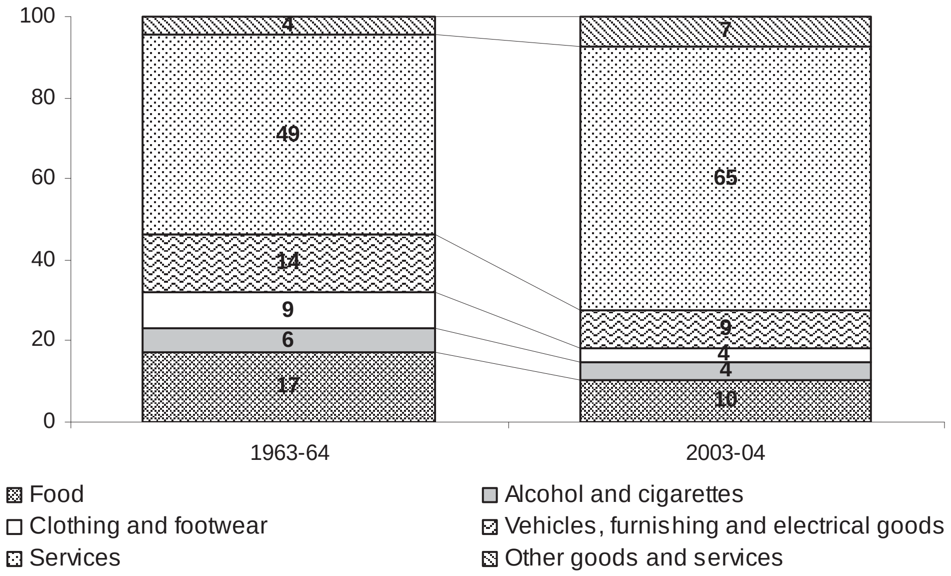
10 This relationship is one of the best established empirical regularities in economics and was first observed by the 19th century German statistician, Ernst Engel. Engel's Law states that the lower a family's income, the greater is the proportion of it spent on food (Rowthorn and Ramaswamy 1997).

Figure 2.13 **Australian household final consumption expenditure shares, 1963-64 and 2003-04[a]**

Per cent, current prices



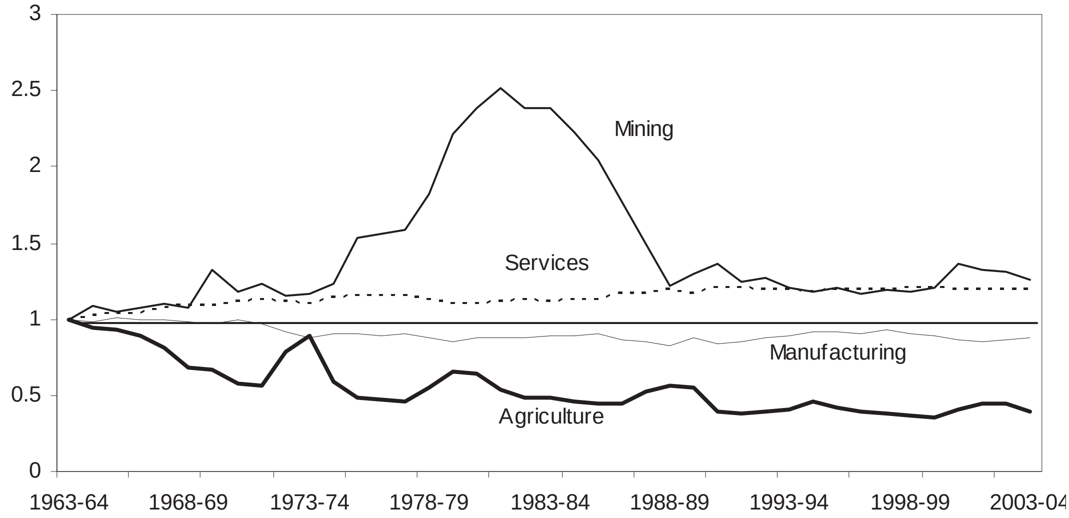
[a] 'Services' comprise household expenditures on: health; education; insurance and other financial services; hotels, cafes and restaurants; recreation and culture; electricity, gas and other fuels; rent and other dwelling services; transport and communications. Totals do not sum to 100 due to rounding.

Data source: ABS (Cat. no. 5206.0).

Changes in the relative prices of goods and services

The relative prices of goods and services produced by different sectors of the economy have changed significantly over time. These changes can have large effects on sectoral incomes and substantial impacts on the relative sector shares of GDP. Overall, the prices received for agricultural commodities more than halved relative to prices received for the products for all industries over the past four decades (figure 2.14). Along with mining (particularly during the minerals boom of the 1970s and 1980s), prices for agricultural commodities have also been highly volatile. Over the same period, prices for the goods produced by the manufacturing sector also declined by around 15 per cent relative to prices for all industries. In contrast, the prices of services rose steadily (both in absolute and relative terms).

Figure 2.14 **Relative prices by sector[a], 1963-64 to 2003-04**



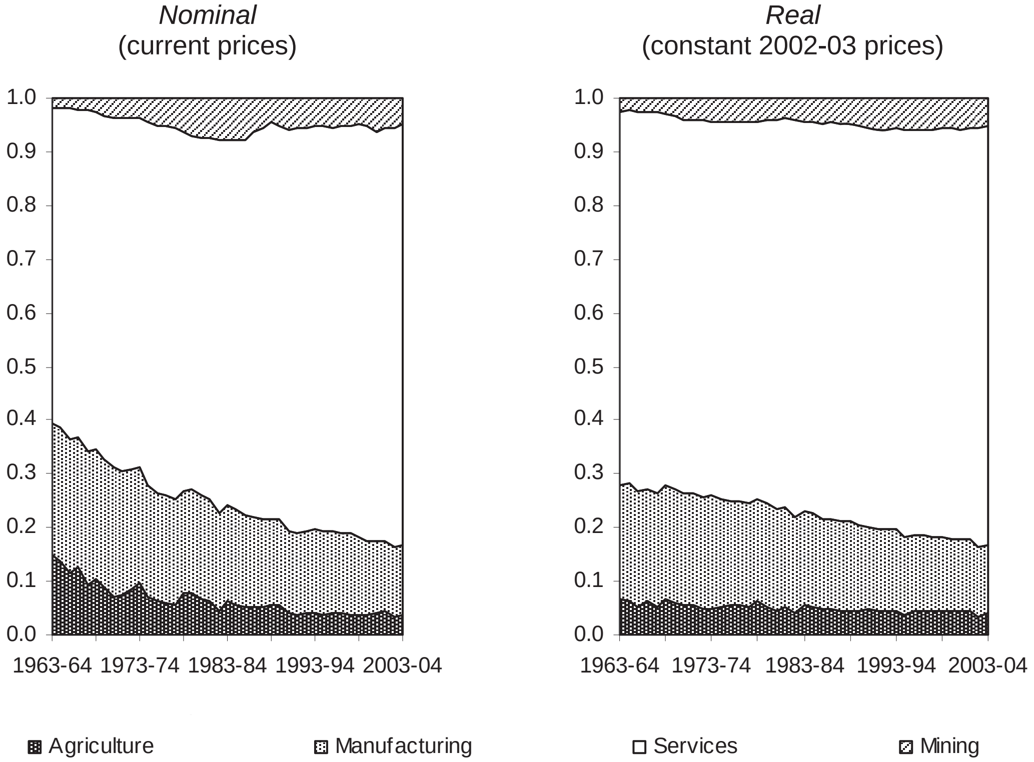
[a] The figure shows the ratio of prices for each sector to an all industries price index. Prices were derived by dividing nominal output by real output. 1963-64 is the base year.

Data sources: ABS (Cat. no. 5204.0) and PC (2003).

These changes in relative prices have contributed to the decline in the share of GDP accounted for by agriculture discussed earlier. For example, when constant price shares of GDP are employed, the share of GDP accounted for by agriculture falls by only 2 percentage points over the past four decades, compared with a fall of 10 percentage points when current prices are used (figure 2.15). In other words, around 80 per cent of the decline in agriculture's output share can be accounted for by the decline in its prices relative to that of other goods and services.

Caution should be exercised in comparing the changes in relative prices of goods in different sectors due to a number of problems including those associated with measuring the output of the service sector and significant changes in the composition of manufacturing and service sector outputs over the period (McLachlan et al. 2002). Nevertheless, the magnitude of the differences in price trends between services and the goods sectors indicates that changes in relative prices have played an important part in the declining output share of the agriculture sector. However, the sharp decline in the employment share noted earlier cannot be solely attributed to price/demand factors.

Figure 2.15 **Nominal and real[a] sectoral share changes, 1963-64 to 2003-04**



[a] The choice of base year affects the magnitudes of constant price sector shares. For example, using a base year at the beginning of the period results in higher agriculture GDP shares for all years. Nevertheless, the relative *changes* in sector shares are largely unaffected by the chosen base year.

Data sources: ABS (Cat. no. 5204.0) and PC (2003).

Technological change/innovation and its impact on agricultural productivity

Australia's agriculture sector has a history of innovation. Examples include the introduction of the stump jump plough and combine harvester at the turn of the last century; large scale irrigation via artesian water and dams; improvements in ground preparation and disease and weed control through the use of advanced chemicals and fertilisers; and the employment of satellite technology to aid in land use decisions and to guide and control spraying and cultivation equipment (ABS 2002a).

The uptake of new or improved production techniques, together with increased mechanisation of many aspects of agriculture production, has made it possible to produce more food with fewer workers, thus freeing up labour for use in other sectors. Australian data confirm that multifactor productivity has risen faster in agriculture than in the service sector (discussed further in chapter 6). Similarly, international evidence indicates that technical innovation associated with agricultural productivity growth is labour saving, permitting a reduction of the share of labour devoted to production (Johnson 2000). Moreover, international multifactor productivity growth rates tend to be higher in agriculture than other sectors (Martin and Mitra 2001).

Taken together, these factors are seen as being responsible for much of the relative decline of agriculture in Australia (and other OECD countries). However, far from being a sign of systemic weakness, this decline reflects positive factors — principally improved productivity and falling relative prices for food coupled with rising demand for services as incomes rise. These are all features of an efficient, high-income economy.

3 Trends within agriculture

Key points

- Over the twenty year period to 2002-03, there have been considerable structural changes *within* agriculture.
- The number of farms in Australia declined from around 178 000 to 132 000, or by around a quarter.
- The total area of land used for agricultural production declined by around 9 per cent.
- The average size of Australian farms increased:
  - the physical size of farms increased from 2720 to 3340 hectares or by around 23 per cent; and
  - the proportion of farms with a value of operations of less than $100 000 declined by 13 percentage points; while the proportion of farms with a value of operations over $500 000 increased by around 8 percentage points.
- Notwithstanding the trend towards larger farms, Australian agriculture continues to be dominated by small farms. In 2002-03:
  - around 20 per cent of farms were under 50 hectares, 10 per cent were between 50 and 99 hectares and 33 per cent of farms were between 100 and 499 hectares; and
  - 31 per cent of farms (or around 41 000 farms) had a value of operations of less than $50 000 and 17 per cent of farms had a value of operations between $50 000 and $100 000.
- Farm production, however, has become more concentrated on large farms — the top 20 per cent of broadacre farms now account for around 64 per cent of output.
- Other notable trends include a shift to more intensive farming and greater integration of production along the agri-food chain.
- In terms of output growth and changes in farm numbers, there is significant variation across agricultural industries:
  - there are slow or declining growth industries such as pigs, eggs and sheep;
  - average performing industries (recording output growth rates and changes in farm numbers broadly in line with the sector average) — including sugar, beef, grains, vegetables, fruit and nuts; and
  - high growth industries such as poultry, grapes, cotton, nurseries and dairy.

Farming in Australia has been changing. Over the last two decades, Australian farmers have had to respond to a diverse array of adjustment pressures emanating from the globalisation of markets, a continuing decline in their terms of trade, new technologies, changing consumer tastes and attitudes and emerging environmental concerns. Changes in government policies, such as the rationalisation of statutory marketing arrangements, together with reforms in areas such as water and land use, have also influenced the environment in which farmers operate and provided further pressures for adjustment.

Australian farmers have responded to these adjustment pressures by changing the size and output mix of their farms, as well as the management and marketing strategies they employ.

While the previous chapter looked at the changing role of agriculture in the economy as a whole, this chapter explores some of the key trends occurring *within* the sector over the last two decades, including:

- fewer and larger farms;
- increased concentration of farm output on larger farms;
- the adoption of more intensive farming techniques; and
- the closer integration of production and related activities in the agri-food chain.

However, the agriculture sector[1] is highly diverse and there have been significant differences in output growth and changes in farm numbers among the industries making up the sector. For this reason, the chapter also examines how the different industries have responded to adjustment pressures and the implications for the composition of agricultural output and farm types.

3.1 Fewer and larger farms

The last two decades have seen a significant decline in the number of Australian farms. Over the period 1982-83 to 2002-03, the number of farms fell by around one-quarter — from almost 178 000 to 132 000 (figure 3.1).

Due to changes in the definition of agricultural establishments (reflected by breaks in the data series in figure 3.1), it is not possible to quantify the annual average rate at which farm numbers have declined for the entire 20 year period. However, the comparable data suggests that farm numbers have declined at a fairly constant rate over the period. Over the periods 1982-83 to 1985-86 and 1986-87 to 1990-91, farm numbers declined at an average annual rate of around 1 per cent, while between

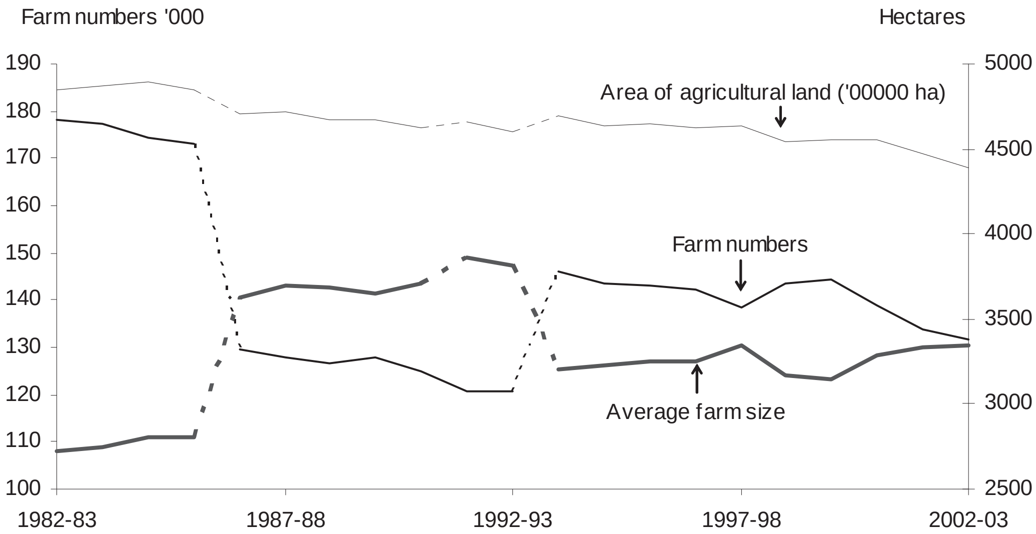
[1] This chapter examines trends within farming or what is traditionally known as ‘agriculture’.

1993-94 and 2002-03 they declined at a marginally faster rate — around 1.2 per cent a year.

Declining farm numbers have also been accompanied by a decline in the area of land in agricultural production — a decline of around 9 per cent over the last twenty years (figure 3.1). While the area of agricultural land remained largely unchanged between 1982-83 and 1985-86, it declined at an average annual rate of 0.4 per cent between 1986-87 and 1990-91 and by 0.7 per cent over the period 1993-94 to 2002-03.

As farm numbers have tended to decline at a faster rate than the area of agricultural land, average farm size has increased. This increase has occurred not only in terms of the input measure of the physical size of land used, but also in terms of the output measure of economic size reflected by the estimated value of farm operations (box 3.1).

Figure 3.1 **Farm numbers, farm size and area of agricultural land[ab], 1982-83 to 2003-04**



a Farm numbers refer to business establishments engaged in productive agricultural activities, typically at one physical location. **b** Breaks in the series reflect periodic revisions to the minimum threshold for inclusion of establishments, based on the estimated value of agricultural operations (EVAO). Until 1985–86, farm numbers included agricultural establishments with an EVAO of $2500 or more. In 1986-87, the EVAO threshold was raised to $20 000, and from 1991–92 it was raised to $22 500. From 1993-94, the EVAO was reduced to include establishments with an EVAO of $5000 or more. Estimates of the number of establishments and average farm size are, therefore, not strictly comparable between periods with differing EVAO thresholds.

Data source: ABS (Cat no. 7121.0).

Box 3.1 **Measuring farm size**

There are two common measures of farm size — physical measures such as hectares operated and financial or economic measures such as value of production. Each measure has advantages and drawbacks depending on its application.

Physical size provides a valuable indicator of the scale of operations. However, it has shortcomings in that it is unable to reflect differences between geographic locations and industries in regard to the productive capabilities of land and differing intensities of land use.

Economic size, on the other hand, provides a measure of size which reflects the aggregate value of output. However, it is sensitive to price and production fluctuations in the short run, and inflation in the long run. It is also unable to reflect differing turnover intensities of different farming systems.

Increasing average physical size

In 2002-03, the average Australian farm was 3340 hectares. This was up from 2720 hectares in 1982-83, an increase of around 23 per cent. Average farm size, however, masks considerable variation in physical farm size (box 3.2).

Over the period 1982-83 to 1985-86, farms increased in physical size at an average annual rate of 1 per cent, while over the periods 1986-87 to 1990-91 and 1993-94 to 2002-03, the rate of average annual growth in farm size halved to around 0.5 per cent (figure 3.1).

The proportion of farms in the three smallest farm size categories (0–49, 50–99 and 100–499 hectares), all declined over the period 1982-83 to 2002-03 — falling by 3.2, 1.7 and 0.8 percentage points, respectively — while the share of medium and, to a lesser extent, large farms increased. The largest increase — 3.2 percentage points — occurred in medium sized farms of between 2500 and 24 999 hectares (figure 3.2).

Notwithstanding the trend towards larger farm size, as illustrated in figure 3.2, small farms continue to dominate the count of farms in Australian agriculture — in 2002-03, 63 per cent of farms were less than 500 hectares. Farms of over 2500 hectares accounted for around 11 per cent of farms.

The median farm size in Australia, however, has remained in the 100–499 hectare range since 1982-83.

Box 3.2 Facts about the size of Australian farms

Australian farms range in size from small hobby and horticultural properties to large grazing and cropping farms.

In 2002-03:

- farms under 50 hectares accounted for around 20 per cent of farms (25 400). Most of these farms were engaged in grape growing, beef cattle grazing, fruit growing, vegetable growing and plant nursery operations;
- 33 per cent of farms were sized between 100 and 499 hectares. Farms in this category were mainly engaged in beef cattle farming, dairying, sheep grazing and grain growing;
- farms over 2500 hectares accounted for 11 per cent of all farms and were mainly engaged in grazing or cropping. A significant proportion of these extensive sheep, beef and mixed livestock operations are located in the arid pastoral zone of inland Australia;
- the median estimated value of operations (EVAO) of all Australian farms was $109 000;
- around 17 per cent of farms (21 600) had an EVAO below $22 500, while around 11 per cent (14 100) had an EVAO of more than $500 000;
- the smallest EVAO category (below $22 500) is largely made up of beef cattle and sheep farms. Other industries with a relatively high proportion of farms in this category include fruit and vegetables, grape growing, horse farming, nurseries and cut flowers; and
- farms engaged in cotton growing, poultry raising, egg production and pig farming had a high proportion of farms with an EVAO of more than $500 000.

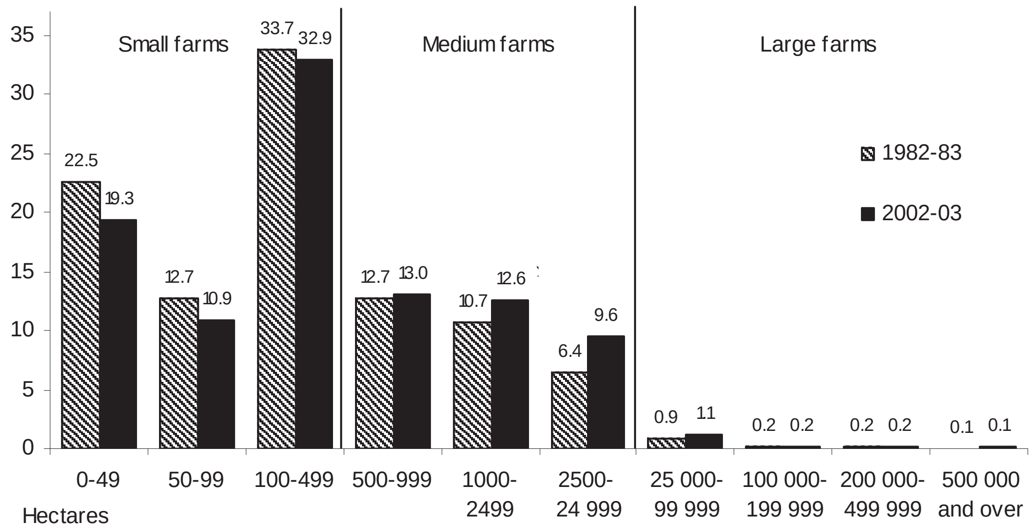
Source: ABS (Cat. no. 7121.0).

Much of the decline in small farms was experienced in the grain, mixed grain and livestock, mixed livestock, pig and cotton industries (accounting for over one-third of the decline). In each of these industries, the decline in small farms translated almost directly to an increase in the proportion of farms in the medium farm category.

The shift towards larger farms has been most evident in cotton, grains, and pig farming. The share of medium and large farms (those with greater than 500 hectares) in these industries increased by 32, 18 and 10 percentage points respectively over the 20 years to 2002-03. In line with the general trend across the sector, the increase in farm size in these industries was most apparent during the 1980s.

Figure 3.2 **Distribution of farms by physical size (hectares), 1982-83 and 2002-03**

Per cent



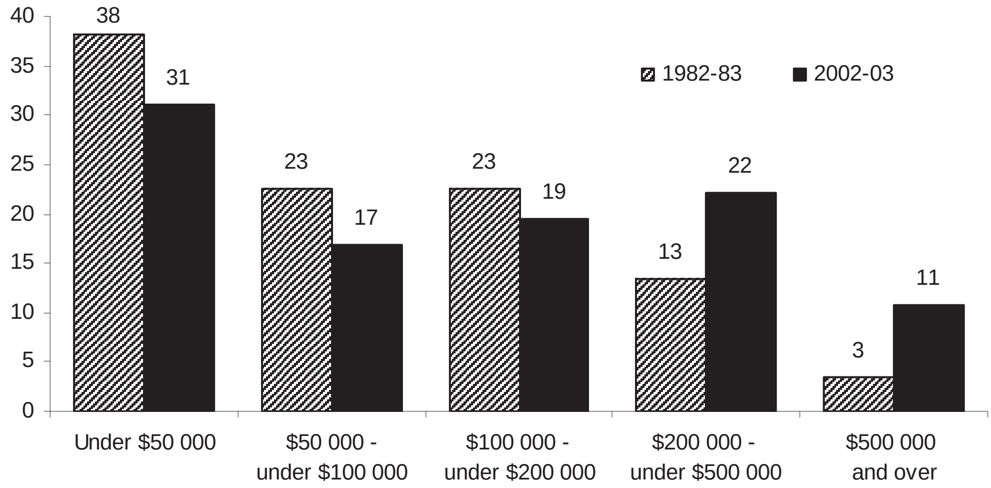
Data source: ABS (Cat no. 7121.0).

Economic measure — value of operations

The trend towards increasing farm size is also evident when an economic measure of farm size is used. An examination of changes in the distribution of farms by value of output over the twenty years to 2002-03 indicates that:

- the greatest decline in farm numbers occurred within the smallest sized farm grouping (farms with a value of operations of less than $50 000). The proportion of farms in this category declined from 38 to 31 per cent;
- farms with a value of operations between $50 000 and $100 000 also declined — by around 6 percentage points;
- the proportion of large farms, those with a value of production over $500 000, increased by around 8 percentage points (figure 3.3).

Figure 3.3 **Distribution of farms by value of output[a], 1982-83 and 2002-03**
Per cent (constant 2004 prices)



[a] Constant price estimates of the value of output (in 2004 dollars) were produced by deflating EVAO by the GDP implicit price deflator.

Data sources: Unpublished ABS data; Econdata.

Trends not unique to Australia

The trend toward fewer and larger farms is not unique to Australia but is common to most developed countries.

Even in countries where farmers are heavily subsidised, such as the United States and the European Union, farm numbers have declined at a similar rate to that experienced in Australia. The annual decline in farm numbers for OECD countries as a whole averaged around 1.5 per cent over the period 1970–90 (OECD 1998, p. 31).

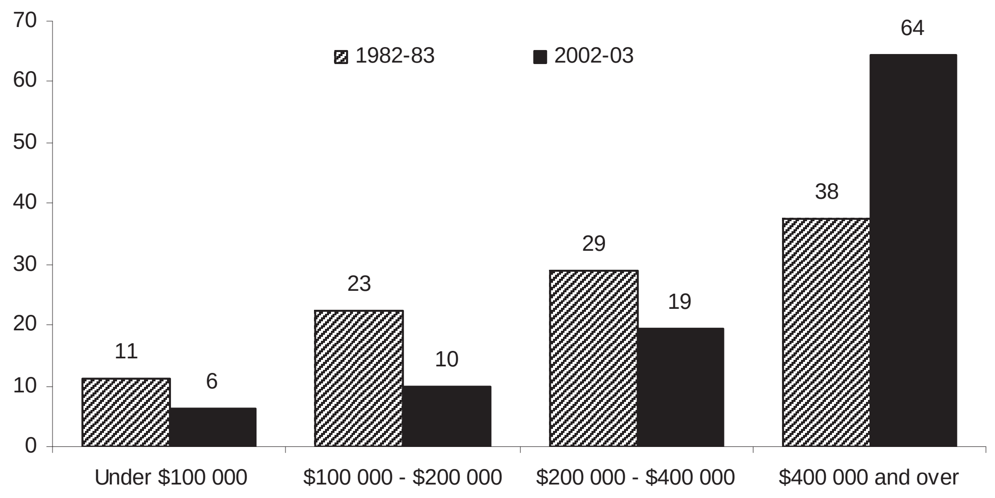
3.2 Increased concentration of output

One of the consequences of the increase in farm size is increased concentration of output on larger farms. It is estimated that 10 per cent of Australian farm businesses account for over 50 per cent of farm output, while the smallest 50 per cent of farms account for 10 per cent of gross farm output (Barr 2003, Corish 2004).

ABARE surveys of broadacre farms — which comprised around 70 per cent of all farms in 2002-03 — also show that while the proportion of farms in the largest economic size category (over $400 000 in value of farm production) increased by 10 percentage points over the last two decades to 20 per cent of farms, their share of the value of production increased from around 38 to 64 per cent — almost three times the increase in the share of farms in this category (figure 3.4). Over the same period, the contribution of farms in the smallest category (under $100 000 in value of farm production or around 40 per cent of farms) declined by almost half to around 6 per cent of the total value of broadacre farm production.

Figure 3.4 **Share of the value of broadacre farm production by value of output[ab], 1982-83 to 2002-03**

Per cent (constant 2002-03 prices)



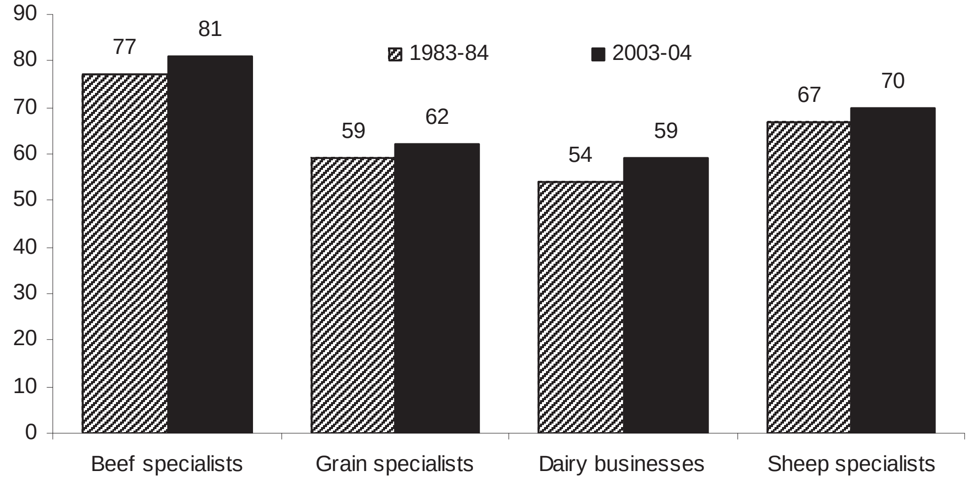
[a] Data include only broadacre farms grouped by farm size on the basis of value of farm production. Value of farm production as defined by ABARE includes total farm cash receipts plus the build up in trading stock. [B] Broadacre farms include sheep, beef, mixed sheep-beef, grains and mixed livestock and crop industries.

Data source: Unpublished ABARE data from Australia Agricultural and Grazing Industries Survey.

And, while there is evidence of increased concentration of output at the industry level, there is some variation in the level of concentration across different industries (figure 3.5). In the beef industry, for example, in 2003-04 the top 30 per cent of farms (in terms of value of output) produced more than 80 per cent of industry output, while in the dairy industry the top 30 per cent produced around 60 per cent of industry output.

Figure 3.5 **Share of industry output produced by the largest 30 per cent of producers, 1983-84 and 2003-04[ab]**

Per cent



a Ranked by value of output. **b** Sheep specialists includes both sheep meat and wool specialists.

Data source: Department of Agriculture, Fisheries and Forestry (2005).

Concentration has accentuated the dual nature of the sector

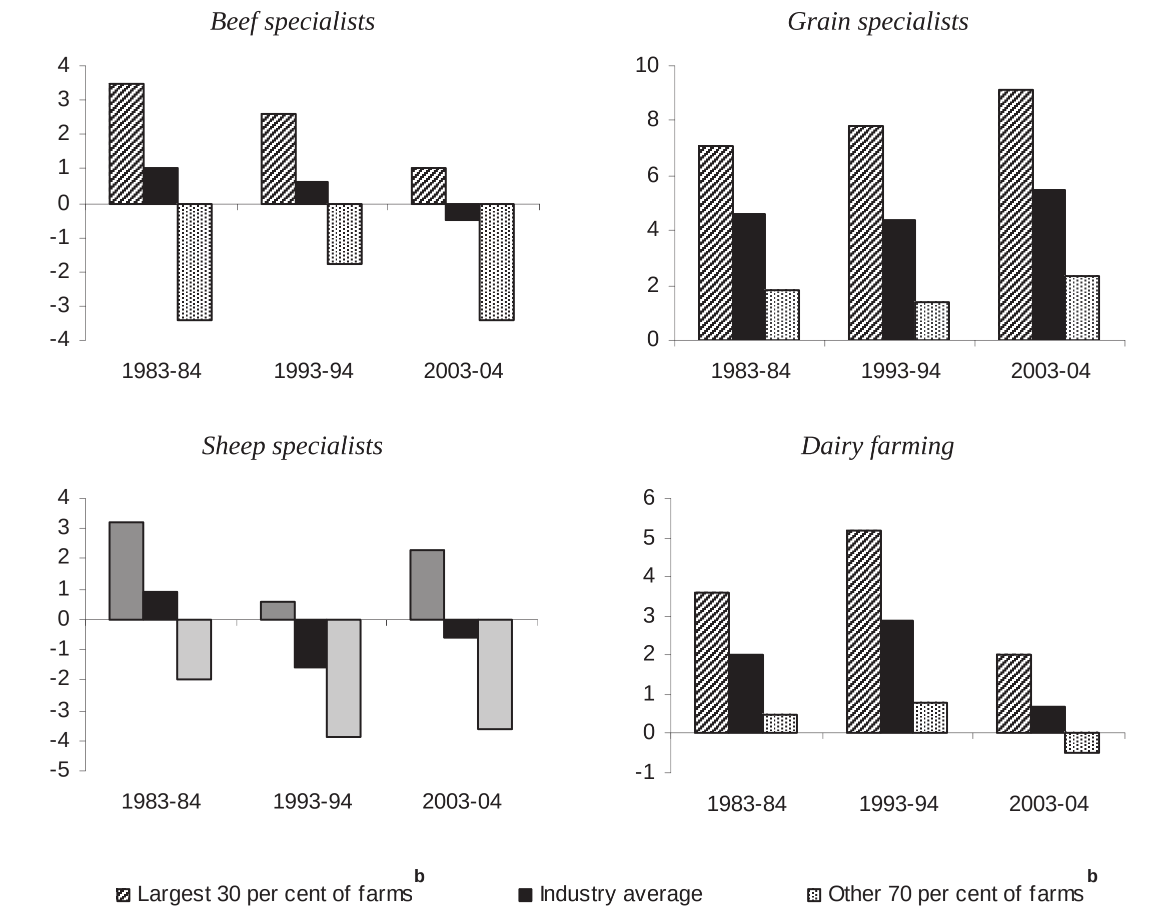
The trend towards increased concentration of output has accentuated the dualistic nature of Australia's agriculture sector — where a small number of large-scale commercial farms produce the majority of agricultural output while small-scale or niche farms (which make up the majority of farms) account for only a small proportion of output. Many of the smaller farms tend to be operated by 'lifestyle farmers', who farm part-time and supplement their income from off-farm sources. These farms are particularly prevalent on the fringes of major metropolitan and regional centres.

ABARE data indicate that smaller broadacre and dairy farms generate considerably lower rates of return than larger farms (figure 3.6). That said, because of the high proportion of small farms in many agricultural industries, average rates of return can appear low. Average returns generated by larger farms (those producing the majority of output), however, are comparable with investment returns elsewhere in the Australian economy. As Martin et al. (2005, p. 19) note:

> Returns on investment in agricultural industries are often low when reported across a whole industry. However, low average returns are partly a consequence of the generally high proportion of small farms in many industries, particularly the beef and sheep industries. The presence of these small farms masks the much higher returns from better performing and larger farms that generate the majority of each industry's output.

The average returns from these better performing and larger farm businesses are frequently comparable with investment returns elsewhere in the Australian economy.

Figure 3.6 **Farm size and rate of return[a], 1983-84, 1993-94 and 2003-04**
Per cent



[a] Excluding capital appreciation and adjusted to full equity by adding interest paid to farm business profit.
[b] Ranked by value of output.

Data sources: ABARE Farm Surveys; Department of Agriculture, Fisheries and Forestry (2005).

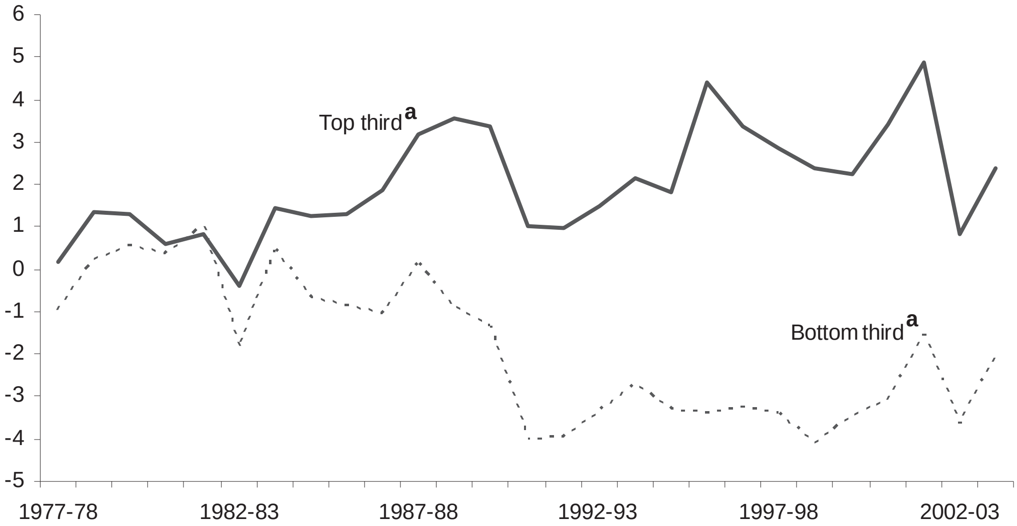
ABARE (Hooper et al. 2002) found that when farms were ranked by size (measured by physical farm area), the farm cash income (total cash receipts less total cash costs) of the largest third of farms was generally two to four times greater than that of the smallest farms over the 25 years to 2000-01. Also, when farm size was measured using sheep equivalents[2], the largest third of farms performed more strongly over the last 25 years than the smaller farms. Notably, there was also

[2] The sheep equivalent measure is widely accepted as an indicator of the productive capacity of farms in different industries. It allows comparisons on an equivalent basis of the size of a farm by reflecting the differing feed requirements of various livestock and or the equivalent potential capacity of land used for cropping purposes.

evidence of an upward trend in rates of return for the top third of farms and a downward trend for the bottom third (figure 3.7). As Hooper et al. (2002 p. 496) put it:

> Regardless of the method used to rank farm size, the results for farm financial performance over the past ten years are consistent. And that is, there is both an income and rate of return advantage to being big.

Figure 3.7 **Rate of return for broadacre farms, 1977-78 to 2003-04**
Per cent



a Average rate of return for broadacre farms ranked by sheep equivalents.

Data sources: ABARE Farm Surveys; Hooper et al. (2002).

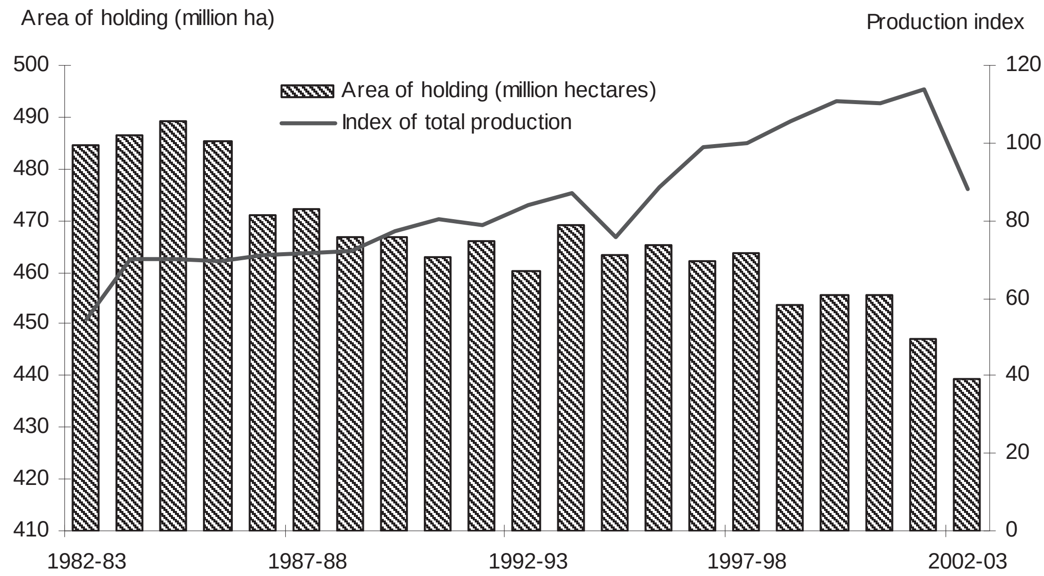
With such financial outcomes, the continued prevalence of small farms can in part be attributed to an increasing reliance by these farms on off-farm income sources to offset negative or low levels of farm-based income (see chapter 5).

For commercial farmers, declining agricultural terms of trade have encouraged the expansion of farming operations in order to capture economies of scale available to larger enterprises. Hooper et al. (2002) suggest that larger farms, particularly those in the cropping, and to a lesser extent, in the broadacre livestock industries have generally been able to capture more of the benefits from new technologies and have therefore achieved much higher growth in productivity over the past two decades (see chapter 6).

3.3 More intensive farming

Intensification of production has been an important adjustment strategy for farmers in many agricultural industries as a means of improving productivity on farms. The trend towards more intensive farming has resulted in higher output despite less land being used for agriculture (figure 3.8).

Figure 3.8 **Trends towards intensification of land use, 1982-83 to 2002-03**



Data sources: Unpublished ABS data; ABARE (2003).

Two factors have contributed to the intensification of agricultural production:

- a structural shift to industries using more intensive production systems — this is known as the 'between' industry effect; and
- more intensive production techniques being used by existing industries — this includes greater use of inputs such as feed, chemicals and irrigation systems to achieve higher production yields. This is known as the 'within' industry effect.

The 'between' industry effect can been seen in both the faster output growth rates and the below average decline in farm numbers occurring in many intensive industries, including, for example, poultry, grapes, cotton and nurseries, over the last 20 years (see figure 3.11).

In terms of the 'within' industry effect, greater intensification in Australian agriculture is taking the form of:

- increased cropping intensity (especially under irrigation);

- greater use of high protein feed concentrates along with irrigated pastures for milk production; and
- a trend toward grain finishing for beef (box 3.3).

Box 3.3 **Intensive production techniques — some examples**

The production of grain-fed beef has more than trebled in the period since 1991-92, with grain fed-beef comprising over 30 per cent of total beef production in 2003-04. The number of cattle being finished in feed lots has been consistently increasing over the decade in response to market demand, from around 200 000 cattle in 1991 to around 700 000 in 2003-04, an average annual increase of around 11 per cent.

In the dairy industry, the past two decades have seen production shift from being largely pasture based toward more intensive production systems. Dairy farmers have enhanced on-farm feed production through irrigation and pasture improvement programs, allowing higher stocking rates. Substantial intensification has also been accomplished through increases in the use of supplementary feeding to boost milk production or to fill seasonal feed shortages. In the decade to 2001-02, the quantity of grain and feed concentrates used in dairy production increased at an average annual rate of around 10 per cent.

Sources: ABARE (2004d); Dairy Australia (2004).

3.4 Closer integration in the agri-food chain

Over the last twenty years, Australian farms have also become more consumer focused. As Keogh (2005, p. 1) observed:

> … in many farm sectors being a farmer is no longer just a matter of growing plants and animals, and delivering them to the auction market that traditionally represents the next step of the market chain that leads to the consumer. Sector-by-sector, farming is progressively being integrated into food and fibre chains, driven by the desire of major food and fibre processors and retailers to reduce chain costs and uncertainty, but also by the desire of farmers to differentiate their produce and increase margins.

This trend has seen an increasing proportion of output supplied to processors or major retailers under comprehensive pre-arranged contracts. For example, over the period 1990-91 to 2003-04, the proportion of beef cattle sold through auction (sale yards) fell from around 65 to 45 per cent. At the same time, the proportion sold over the hook (prearranged specifications for weight, age, fat depth and date of delivery) increased from 22 to 40 percent (Barber and Cutbush 2005).

Contract farming in Australia appears to be most prominent in the fruit and vegetable, wine grapes, poultry and beef industries.

In the citrus industry, for example, many growers have contracts with processors for the supply of juicing oranges. Contracts typically cover terms of three to five years and generally cover a proportion of the grower's crop at an agreed price per tonne (PC 2002).

New technologies which enable producers to exploit economies of scale, have seen the poultry and pig industries become closely controlled, vertically integrated, production-marketing systems. In both these industries, farmers are generally under contract to provide livestock growing-out services to processors who supply all the main inputs — such as, juvenile livestock, feed, medication and technical advice — into the production process. It is estimated that around 85 per cent of poultry meat in Australia is now grown under contract (Tonts and Black 2002, pp. 3–4).

The gradual unwinding of statutory marketing arrangements (SMAs) in many agricultural industries has given farmers more control over how their output is marketed and sold (box 3.4). Previously, under SMAs, marketing controls such as vesting, compulsory acquisition, quotas, price setting, pooling or equalisation gave farmers little incentive or ability to be involved in marketing or processing beyond the farm gate. With the gradual shifting away from highly prescriptive regulation, farmers now have greater choice in the management of their agricultural output, from growing through to processing and packaging.

The closer integration of production and markets has meant that farmers are better able to respond to changing market conditions. For example, the National Competition Council (NCC, 2000, p. 2), commenting on changes to marketing arrangements for the barley industry, including the removal of compulsory marketing arrangements, said:

> Changes in barley marketing are primarily about giving growers a choice as to how, when and to whom, they sell their crops. Growers are increasingly able to take greater control over their businesses and to respond to opportunities as they arise. It also gives purchasers a choice of who they buy barley from and increasingly, choice as to which sort of barley best meets their needs.
>
> In addition, the changing structures of the former statutory marketing authorities are placing them in a stronger, more flexible position to operate effectively in the new business environment and take full advantage of local and international opportunities.

Also, in the dairy industry since the removal of state-based milk marketing regulations, some farmers have explored niche marketing opportunities for high quality and/or organic milk by setting up locally based processing ventures.

Box 3.4 **Changes to some agricultural marketing arrangements**

Historically, compulsory marketing arrangements have been a prominent feature of many of Australia's agriculture industries. Indeed, the bulk of measured assistance to the agriculture sector was once provided through a range of statutory marketing arrangements, regulations and price supports.

Over the last two decades, competition has been gradually introduced into a range of agriculture industries where compulsory statutory marketing arrangements (SMAs) had previously been responsible for all processes between the farm and consumer markets. For example:

- The Queensland Cotton Board was deregulated in 1989. Today all Australian raw cotton is marketed under a competitive system.
- The domestic market for wheat was deregulated in 1989. However, despite a review under National Competition Policy recommending greater liberalisation, single-desk wheat export marking arrangements have been retained.
- In the egg industry, state-based production and pricing controls were progressively withdrawn from the late 1980s, with the remaining state controls in Western Australia due to be withdrawn by the end of 2005. Several major egg marketing groups now compete to supply the domestic market.
- In the early 1990s, the Commonwealth price equalisation levy and statutory equalisation of domestic sales for dried vine fruits was removed, as was the industry's exemption from section 45 of the Trade Practices Act (which effectively reduced the scope for collusive price discrimination.)
- In 1991, the minimum reserve price scheme for wool was abandoned.
- In the tobacco industry, a restructuring program was introduced in 1995 and included the phasing out of local content schemes and import tariffs.
- Competition has gradually been introduced into domestic barley markets in South Australia and Victoria since 1997 with further deregulation of export controls in 2000. Growers can now choose between private traders or pooled marketing services.
- In mid-1997, import tariffs and domestic price supports in the sugar industry were removed. While single desk arrangements for the acquisition and marketing of bulk sugar have been retained from July 2004, exemptions were granted for sugar used in the manufacture of alternative products. Domestic pricing provisions remain in place with producers receiving an average of prices from pooled revenues.
- In the dairy industry, the decision to phase out Commonwealth price supports for manufacturing milk initiated further deregulation, which was accomplished with the removal of state-based milk marketing regulations in mid-2000.
- Despite several National Competition Policy reviews (most recently in late 2004), the NSW rice marketing board retains the legislated power to 'vest, process and market' all rice produced in NSW (around 99 per cent of Australian rice production).

Sources: IC (1998); NCC (2004, http://www.ncc.gov.au); Edwards 2003.

More demand-responsive production is also evident in terms of greater output diversification within the sector, with Australian farmers now producing a wider range of commodities than previously. On broadacre farms, for example, the number of significant enterprises (significant enterprises are defined as any activity contributing more than 10 per cent of farm business receipts) increased from an average of 2.3 per farm in 1990-91 to 2.7 per farm in 1998-99 (Martin et al. 2000).

There is also a trend toward increased diversity for a number of individual commodities, reflecting greater responsiveness to consumer demand for certain features or attributes of agricultural commodities. For example, twenty years ago there was one variety of lettuce grown (iceberg), now the range grown in Australia also includes — cos, coral green, butter, mixed leaves — to name just a few. A not quite so obvious example, is the refinement of grain crops to enhance certain desirable characteristics, such as the development of grains capable of producing omega-3 oils (see CSIRO 2005).

Greater consumer responsiveness is also evident through a range of new and emerging agricultural industries, and the growth of organic farming (box 3.5). Growth in organics has arisen in response to a number of factors including greater consumer health awareness, concerns over the quality and safety of food products and higher incomes.

Box 3.5 **New and emerging industries — some examples**

Wildflowers — Australian exports are estimated to have been around $35 million in 1999-2000. Japan, the United States, the Netherlands, Canada and Germany are Australia's major export markets.

Game meats — including buffalo, camel, crocodile, emu, ostrich, kangaroo — are being farmed and wild harvested for domestic and export markets.

Essential oils — there are around 150 commercial producers in Australia. Tasmania produces commercial quantities of lavender, parsley, peppermint, dill, boronia, blackcurrant bud and fennel. Tea-tree and eucalyptus are the main essential oils produced in New South Wales, while in Victoria it is peppermint. Australia accounts for around 1–2 per cent of world trade in essential oils, with exports valued at US $31.5 million in 1998.

Asian foods — growing domestic consumption arising from greater Asian influence on cuisine has provided recent opportunities for growth. In 2002, the value of Asian vegetable production in Australia was around $136 million, having increased from around $50 million in 1993-94.

(Continued on next page)

Box 3.5 **(continued)**

Native foods — commercially produced native foods include aniseed, myrtle, Davidson's plum, lemon aspen, lemon myrtle, mountain pepper, quandong, wild limes and wattleseed. In 2003-04, the gross value of production for native foods was around $5 million. While average returns across the industry are reputedly low, a recent increase in the take-up of native food products by major supermarkets, both locally and overseas, points to increasing consumer demand.

Organic farming — organics is a multi-output industry involving production without the use of artificial chemicals or genetically modified organisms. In 2003, there were an estimated 1500 certified organic farms in Australia using some 7.9 million hectares (around 1.7 per cent of Australia's agricultural area). A feature of the industry is the high rate of market growth achieved both in Australia and other developed countries over the last decade.

Sources: Department of Agriculture, Fisheries and Forestry (2005); RIRDC (2004); Hallam (2003); Wynen (2003).

3.5 Divergent trends within agriculture

While for the sector as a whole the trend since the mid-1980s has been towards fewer and larger farms, the decline in farm numbers has not uniformly affected all industries in the sector (figure 3.9).

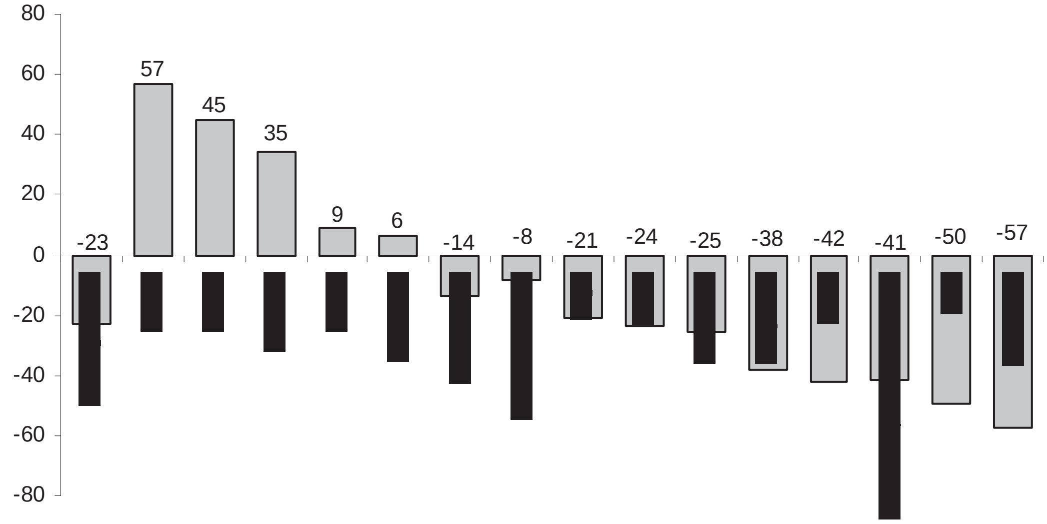
The largest decline in farm numbers was experienced in the pig farming industry — a fall of 57 per cent between 1985-86 and 2002-03. Other industries experiencing significant declines in farm numbers over this period include eggs, sheep (also grain-sheep/grain-beef) and dairy.

Industries going against the sector's trend of declining farm numbers over the period include cotton, grapes, nurseries, poultry and beef cattle.

There has also been considerable variation in rates of output growth across industries over the last two decades (figure 3.10). As expected, the industries recording large increases in farm numbers also recorded trend growth in output above the average for the sector.

Figure 3.9 **Changes in farm numbers, by industry, 1985-86 to 2002-03[a]**

Per cent, average three years ended

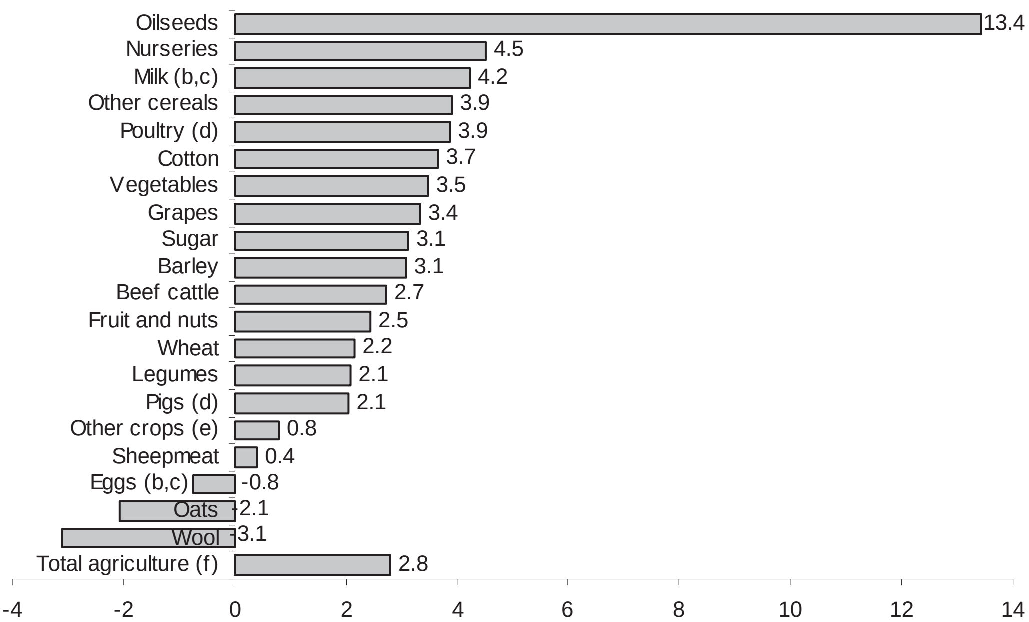


[a] Data for the change in farm numbers are calculated from the average over the three years ended 1985-86 and 2002-03 (to smooth yearly variations).

Data source: ABS (Cat. no 7121.0).

Figure 3.10 **Trend growth in agricultural output[a], 1985-86 to 2002-03**

Per cent



[a] Longest available chain volume time series. Each trend growth rate was estimated by regressing the logged values of the chain volume measure of the value of output against a time trend for all the years 1985-86 to 2002-03. [b] Excludes the Northern Territory prior to 1997-98. [c] Excludes the Northern Territory for 2002-03. [d] Excludes pigs and poultry in Tasmania and the Northern Territory prior to 1997-98. [e] Includes pastures and grasses. Excludes crops for green feed or silage. [f] Includes pigs and poultry slaughtering in Tasmania and the Northern Territory, and livestock products in the Northern Territory.

Data source: Unpublished ABS data.

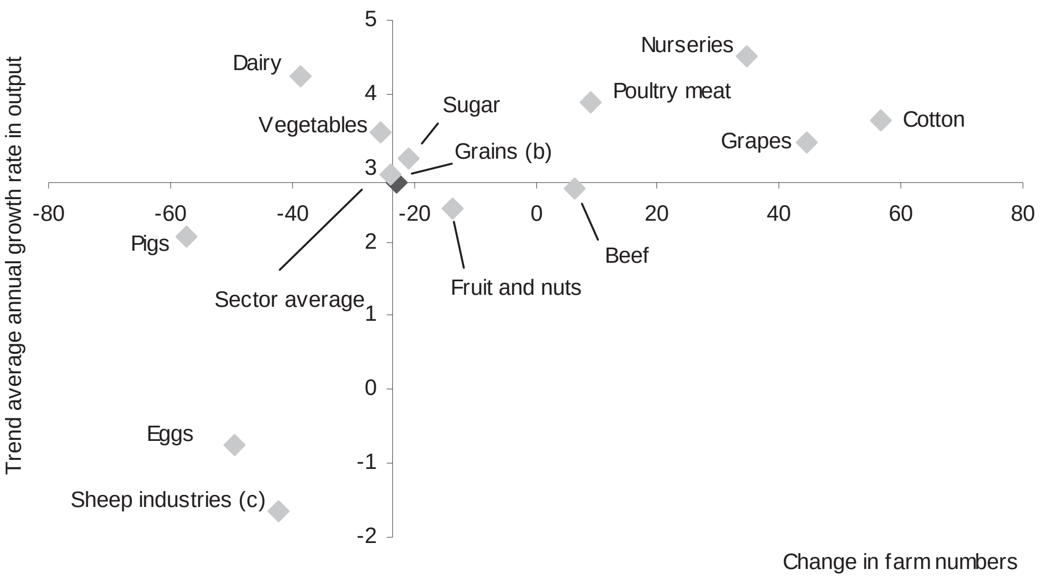
A quadrant analysis, where industries are ranked according to changes in farm numbers and output growth since the mid-1980s, indicates that there are three broad industry groups — average performing industries, slow or declining growth industries and high growth industries (figure 3.11). Some of the factors influencing the trends experienced by these groupings of industries are discussed below.

Average performing industries

Average performing industries — those industries recording output growth rates and changes in farm numbers broadly in line with the sector average since the mid-1980s — include beef, grains, fruit and nuts, vegetables and sugar (figure 3.11). Despite average output growth, the beef, wheat, fruit and nuts and vegetable industries all ranked among the top 5 contributors to overall output growth over the period, reflecting their size and thereby their ability to establish the trends for the sector.

Figure 3.11 **Agricultural industries, growth in the value of output and changes in the farm numbers[a], 1985-86 to 2002-03**

Per cent



[a] Data for the change in farm numbers are calculated from the average over the three years ended 1985-86 and 2002-03 (to smooth yearly variations). [b] Trend growth for grains was estimated based on an average chain volume index reflecting the relevant commodities (barley, oats, wheat, other cereal grain, legumes and oilseeds) [c] Trend growth for sheep industries was estimated based on an average chain volume index reflecting the relevant commodities (sheep, lambs and wool).

Data sources: Unpublished ABS Data; ABS (Cat no. 7121.0).

While the grains industry ranked as an average performer over the period, within the industry there has been considerable variation in output performance between crop types. Oilseeds, for example, recorded output growth almost 5 times higher than the sector average over the period (figure 3.10). This largely reflects the rapid growth in output of canola (Australia's main oilseed crop) since the early 1990s. Production of canola increased from around 87 000 tonnes in 1985-86 to 1.8 million tonnes in 2002-03, an average annual trend growth rate of around 27 per cent. On the other hand, wheat, legumes and oats recorded output growth slower than the sector average (figure 3.10).

Slow or declining growth industries

The sheep, pig and egg industries experienced both slower output growth rates and greater declines in farm numbers than the sector's average since the mid-1980s (figure 3.11). Despite similar trends in these industries, differing influences have been driving the changes.

In the sheep industry, the dismantling of statutory marketing arrangements for wool, weak demand for wool and low returns for wool production relative to other farm enterprises throughout the 1990s, saw many farmers move out of wool. Sheep numbers declined from a peak of 173 million in 1989-90 to around 97 million in 2002-03 (Hooper et al. 2003) and the number of sheep farms almost halved over the period 1985-86 to 2002-03.

Economies of scale and productivity gains available to large specialist pigmeat producers encouraged production consolidation towards larger farms and saw the industry transformed from a sideline industry associated with other agricultural production (such as grain and dairy farming) to an intensive grain-fed specialist farming industry (PC 2004a).

In the egg industry, the number of farms has halved since the mid-1980s. This was jointly influenced by a long-term decline in per capita egg consumption (box 3.6) and restructuring associated with the rationalisation of industry regulation. Economies of scale achievable on larger egg farms, together with selective breeding, have seen productivity improvements, such that remaining producers have achieved increases in egg production despite a fall in total bird numbers (PC 1998).

High growth industries

Industries that stand out as having experienced both an increase in farm numbers and output growth above the sector average over the period include poultry meat, grapes, cotton and nurseries. The dairy industry is an exception — achieving output growth above the average for the sector while structural changes within the industry have led to fewer and larger farms (see chapter 6, box 6.1).

Growth in the poultry meat industry has been largely fuelled by shifts in consumers' eating patterns away from red meat to white meat consumption (box 3.6). Chicken meat now rivals beef as Australian consumers' most popular meat (RIRDC 2003).

Exports have largely driven the growth in wine grape production — which has almost trebled since the mid-1980s. In terms of farm numbers, the industry has expanded by around 80 per cent since 1992-93 (see chapter 4, box 4.2).

Box 3.6 **Australians' changing diets**

Over the past two decades, food consumption patterns in Australia have undergone some notable changes. While changes in relative prices and income levels have contributed to these changes, other factors have also been relevant including:

- population ageing and changing household size;
- the influence of convenience considerations;
- concerns regarding health and food safety; and
- ethical considerations regarding the treatment of animals and the environment.

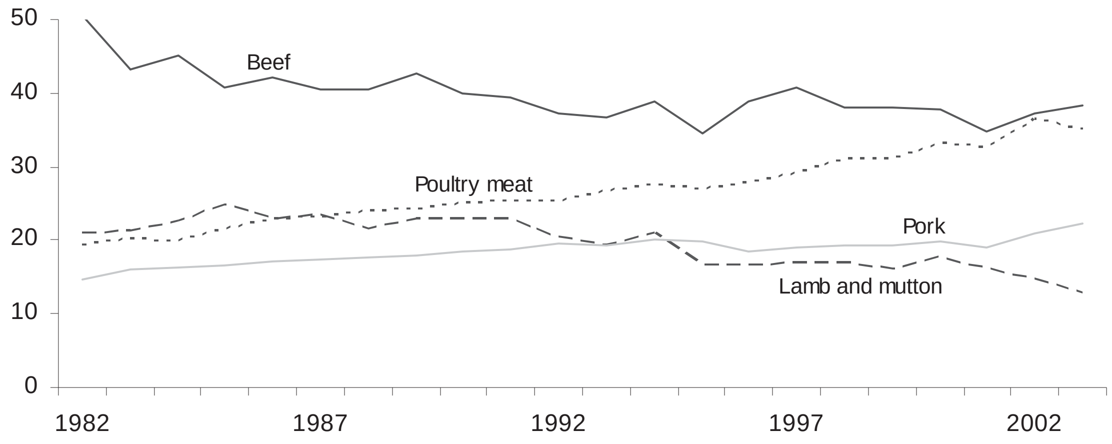
Expenditure shares between the main commodity staples (meat, cereal, fruit and vegetables) have tended to converge in recent years, indicating a broad trend toward achieving a 'balanced diet'. That said, some commodities have experienced sizeable consumption falls, while others have experienced booming demand.

- While overall meat consumption has remained relatively static, since the late 1970's seafood and poultry have both increased their share — seafood consumption doubled to around 10 per cent of meat consumption, while the share of poultry meat increased to almost 30 per cent of meat consumption (figure 3.12).
- Fruit and vegetable consumption increased by almost 40 per cent between 1978-79 and 1998-99, from around 213 to 297 kg per capita.
- Per capita egg consumption declined from 220 in 1978-79 to around 137 in 1998-99, a fall of around 34 per cent.
- Rice consumption more than doubled over the period 1978-79 to 1998-99, from 2.4 to 7.1 kg per capita.

(continued on next page)

Box 3.6 **(continued)**

Figure 3.12 **Meat consumption trends[a], per capita**
Kilograms



a Beef, lamb and mutton and pig meat production are expressed in carcass weight.

Data sources: ABARE (2004b).

In addition, two significant changes in overall diet have emerged.

- Consumption has tended to shift toward more processed and pre-prepared foods, with substantial increases in expenditure on frozen meals (47 per cent) and other prepared meals (68 per cent) between 1993–94 and 1998–99.
- The share of meals consumed away from home has increased to account for 27 per cent of all food expenditure in 1998–99, an increase of around 9 percentage points in the share of total food expenditure since 1984.

Sources: ABS (Cat. nos. 4306.0; 6535.0); Lester (1994); ABARE (2004b).

The cotton industry has recorded an average increase in production of around 3.7 per cent each year since 1985-86. The expansion followed the completion of dams and irrigation infrastructure in a relatively concentrated area around the major river basins of northern New South Wales and southern Queensland. There has been a strong trend towards larger farms in the industry — the proportion of medium and large farms (those with greater than 500 hectares) increased by just over 32 per cent over the last two decades, while the proportion of farms with a value of operations of $500 000 or greater increased by around 15 percentage points.

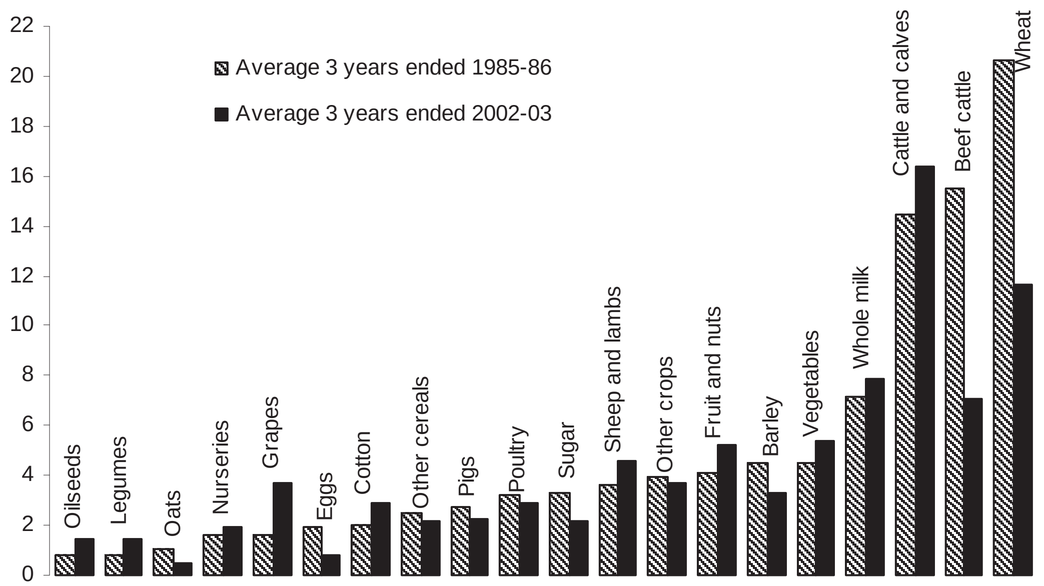
The nursery industry recorded the second highest growth in output over the period — an average annual trend growth rate of 4.5 per cent. This high growth rate, however, was from a small base and, as such, nurseries made only a small contribution to output growth for the sector as a whole.

The changing composition of agriculture

Reflecting the variations in output growth rates and farm number changes across industries, the composition of the agriculture sector has changed since the mid-1980s (figure 3.13). While wheat, beef and wool have dominated Australian agriculture both in terms of output and farm numbers over the period, the combined share of these activities has declined — in terms of output, the share accounted for by the 'big three' declined from around 50 per cent of the gross value of production to around 35 per cent.

Figure 3.13 **Composition of agriculture output, gross value of production 1985-86 and 2002-03[a]**

Per cent, average three years ended



[a] Data for the composition of output are calculated from the average over the three years ended 1985-86 and 2002-03 (to smooth yearly variations).

Data source: Unpublished ABS data.

As may be expected, 'high growth industries' such as grapes, cotton, nurseries and dairy, increased in relative importance in terms of output over the two decades while the 'slow growth industries' such as wool, pigs and eggs lost output share.

Because Australian agriculture is strongly export oriented, changes in the composition of output are also reflected in the composition of agricultural trade. The next chapter explores key changes in the nature, composition and direction of Australia's agricultural trade.

4 Trade in agriculture

Key points

- Agricultural exports amounted to $28.2 billion in 2003-04 — equivalent to 22 per cent of total goods and services exports. Agricultural products make up 7 of Australia's top 20 exports. Beef, wheat, wine and wool are the largest, with combined earnings of almost $12 billion in 2003-04.
- In 2002, Australia was the 6th largest exporter of agricultural products, accounting for around 3 per cent of global agricultural exports. By comparison, Australia was the 16th largest exporting nation overall, accounting for only 1 per cent of world merchandise exports.
- Australia is an important global player in a number of agricultural commodities. In 2002, Australia accounted for 65 per cent of global wool exports (greasy and scoured); 15 per cent of wheat exports; 15 per cent of bovine meat exports and 9 per cent of wine exports.
- Agricultural exports have experienced steady growth in recent decades. While the sector's reliance on export markets has been increasing, the economy's reliance on these exports has been declining rapidly — down from over two-thirds of total exports in the early 1960s to just over one-fifth in 2003-04. This reflects slower growth in agricultural export volumes and to a lesser extent, declining relative prices for agricultural exports.
- Nevertheless, Australia continues to exhibit a much more rural-based export profile than is the norm for high-income industrialised countries. In 2003, agriculture accounted for less than 10 per cent of OECD exports.
- Australia's agricultural exports have become more diverse in recent decades with less reliance on traditional commodities, such as wool, and more reliance on processed products including wine, cheese, processed foods and seafood. At the same time, the shift in emphasis away from European to Asian markets has continued over the past decade and a half.
- Developing countries are playing an increasingly important role in global agricultural markets, providing both challenges and opportunities for Australian farmers.
- Australia provides the second lowest level of government support to agriculture, after New Zealand, among OECD countries. Despite some reductions in global barriers to trade over the past decade, agriculture remains highly protected in many OECD countries. Although studies have identified substantial potential gains from further liberalisation of agricultural trade, the full benefits are unlikely to be realised for some time. Given the increasing reliance by Australian farmers on overseas markets, productivity improvements remain crucial in maintaining the viability of the sector.

Australian agriculture has a long history of successfully competing on global markets. Recent decades, however, have seen changes in the nature of global agricultural trade, the conditions under which it takes place, as well as the make-up of Australia's agricultural exports.

This chapter explores some of the key changes in the nature, composition and direction of Australia's agricultural trade.

- Section 4.1 looks at how the increasing integration between agriculture and manufacturing has affected agricultural exports and the way they are measured.
- The changing trade orientation of agriculture and its contributions to total Australian and global trade are examined in section 4.2.
- Trends within agricultural exports are examined in section 4.3. Importing trends are briefly canvassed along with changes in the extent of intra-industry trade in agriculture.
- Changes in Australia's export markets for different agricultural commodities since 1990-91 are examined in section 4.4.
- Trends in assistance to Australian agriculture and barriers to international trade in agricultural products are briefly discussed in section 4.5.

Seasonal variations in agricultural production both domestically and globally means that commodity export volumes and prices and the relative importance of different markets are inherently volatile. Because of this, it is difficult to separate longer-term structural shifts from other short and medium term shocks. While it is not possible to completely remove the impact of cyclical factors, where possible, longer-time frames are used as reference points to draw out the more lasting changes and compositional shifts in agricultural exports.

4.1 Measuring agricultural exports

Before examining trends in agricultural trade, it is important to clarify exactly what is meant by the term 'agricultural exports'.

Until recently, measuring the importance of agricultural exports was relatively straightforward as most agricultural production was exported as raw or unprocessed product. Thus, it was possible to compare production quantities or values with export quantities or values for individual commodities.[1] However, an increasing proportion of agricultural output is now being exported in a semi-processed or

[1] After taking into account differences in the valuation basis for production ('farm gate') and exports ('free on board').

manufactured form. This leads to difficulties in determining which industry should be credited with the exports (ABS 2002bc, West 2002, McGovern 1999).

There are two broad classification systems commonly used for defining agricultural exports:

1. *Industry-based classifications* — including the Australian and New Zealand Standard Industrial Classification (ANZSIC); and
2. *Commodity-based classifications* — including the United Nations Standard International Trade Classification (SITC), the Trade Exports Classification (TREC) used by the Department of Foreign Affairs and Trade (DFAT); and the Balance of Payments (BOP) classification used by the Australian Bureau of Statistics.

The ANZSIC provides a framework for classifying businesses to industries according to the predominant activities undertaken by them (it is employed extensively in this report for the discussion of value-added, employment and productivity trends in agriculture). Under ANZSIC, the exporting industry is typically the industry that performs the final activity required to complete the processing or production of the product in question. As such, exports of processed agricultural commodities are classified as manufacturing exports. For example, exports of products like wine, frozen meat, canned food, UHT milk and cheese and woollen products are attributed to the manufacturing sector despite the majority of their value being attributable to the agricultural sector (as discussed in chapter 2).

On the basis of this 'industry-based' framework, the agriculture sector accounted for 8 per cent of total Australian exports in the three years to 2003-04, while the manufacturing sector accounted for almost half of Australia's exports (figure 4.1).

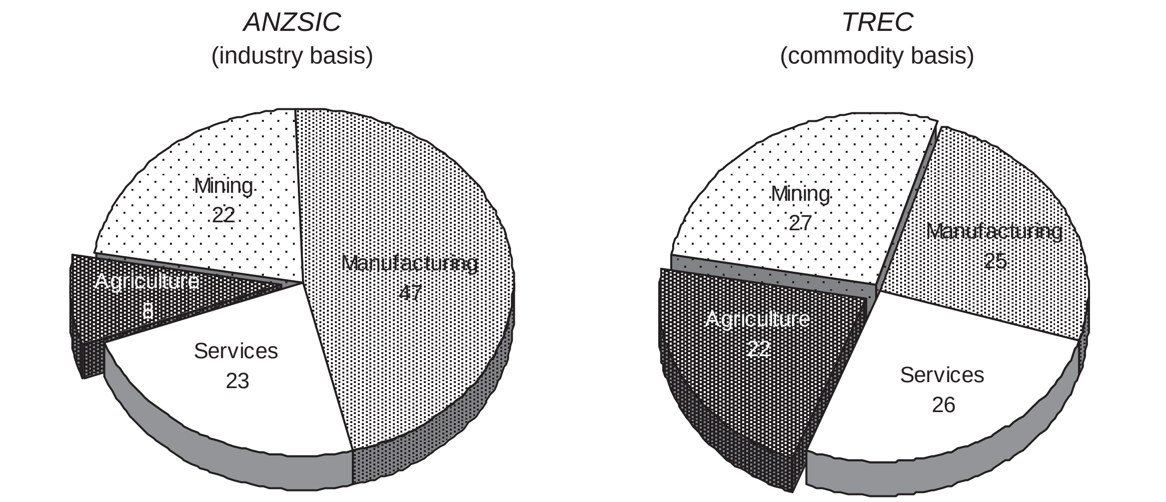
Analysis of input-output data, however, confirm that industry classifications significantly understate agriculture's contribution to total exports. For example, when a narrow definition of beef cattle exports is employed, the sector's export propensity is estimated at 8 per cent. However, 'indirect' beef cattle exports in the form of meat products from abattoirs (part of the manufacturing sector) are more than six times higher than 'direct' exports. When these are included, the estimated export propensity of the industry rises to 58 per cent of production (ABS 2002c).

To overcome this problem, commodity-based estimates of trade in agriculture have been constructed. These generally include exports of agricultural goods that have not undergone significant value-adding by manufacturing firms. The United Nations SITC is the most widely used commodity-based classification and forms the basis for the other systems. It aggregates highly detailed customs trade data into comparable groupings to show the nature of the commodities and the materials used in their production. Under the SITC system, agricultural, or 'rural' exports include most semi-processed agricultural commodities such as sugar, dairy products, frozen and packaged meat and wine.

DFAT uses the TREC system, which regroups SITC data, to allocate trade to various commodity groups based on the degree of value-adding by industries. Using the TREC system, agriculture is estimated to account for around 22 per cent of total exports of goods and services in the three years to 2003-04. This was almost three times its industry-based contribution (figure 4.1).

Figure 4.1 **Two views of the importance of agriculture to Australian exports[a], 2001-02 to 2003-04**

Per cent



[a] Due to confidentiality, some exports are not attributed to any industries in either the TREC or ANZSIC classifications. These exports were omitted from the totals to allow sector shares to sum to 100.

Data sources: ABS (Cat no. 5368.0), DFAT (STARS Database 2005).

By including agricultural exports with at least some degree of value-adding by the manufacturing sector, the TREC and SITC classifications generally provide a better indication of the role the Australian agriculture sector plays in international trade than does the ANZSIC system. And, although there are differences in the way commodities are grouped, the coverage of agricultural exports by SITC and TREC are almost identical.[2] Hence, despite not being directly comparable to the ANZSIC data on agricultural employment and production presented in other chapters, the TREC and SITC classifications are employed in this chapter according to data

[2] For information on the TREC and SITC treatment of agricultural exports see DFAT (2004c).

availability. In instances where chain-volume data are required and for purposes of international comparability, ABS Balance of Payments data are employed.[3]

It should be noted that independent of which ‘commodity’ classification is used, the magnitudes and growth rates of agricultural exports are close (see appendix B, figure B.1). Hence, the use of these different measures interchangeably throughout the chapter is unlikely to be misleading.

However, as the ABS (2002c, p. 101) cautions, the variety of methodologies used to estimate exports (and the assumptions required), means that any estimates of the proportion of agriculture output which is exported, or the relative sector contributions to total exports, will only be an approximation.

4.2 Trade orientation and openness

Australia is a major exporter of agricultural products. For much of the last century, agriculture provided the majority of Australia’s export revenue. In the first half of the twentieth century, agriculture accounted for between 70 and 80 per cent of total goods and services exports (Butlin 1962). And, as recently as 1963-64, agricultural exports accounted for more than two-thirds of the value of total exports (table 4.1).

Over the past four decades, this share has fallen sharply. It more than halved in the two decades between 1963-64 and 1983-84. Since then it has continued to decline in relative importance, although at a much slower rate.

Agricultural export values (and volumes) are driven largely by trends in agriculture output, with droughts having sharp negative effects (box 4.1). Overall, despite a pick-up in 2003-04, agricultural export volumes[4] have not recovered to the pre-drought peak of $34 billion (constant 2002-03 prices) in 2000-01.

The recovery in agricultural exports in 2003-04, however, was short-lived, with a substantial fall in agricultural output (and exports) in 2004-05 due to ongoing drought conditions in much of eastern Australia. Moreover, forecasts by ABARE indicate a fall in crop production of around 17 per cent in 2005-06 with projected strong growth in Western Australian wheat production counteracted by expected substantial falls in the eastern States and South Australia (ABARE 2005b).

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[3] This measure of agricultural exports includes the BOP category ‘rural exports’ as well as two ‘non-rural’ commodities: beverages (predominantly wine) and sugar.

[4] Use of the term ‘export volumes’ throughout the chapter refers to ABS chain volume index (CVI) data unless otherwise stated.

Table 4.1 **Composition of Australian exports by sector[a], 1963-64 to 2003-04**

Per cent

	Average for three years ended				
Sector	*1963-64*	*1973-74*	*1983-84*	*1993-94*	*2003-04*
Agriculture	68.0	46.7	33.0	23.3	21.6
Mining	1.9	19.4	32.5	31.5	30.2
Manufacturing	13.6	19.3	17.0	23.2	24.9
Services	16.5	14.7	17.5	22.0	23.3
Total exports of goods and services	100.0	100.0	100.0	100.0	100.0

a Averages for three years ended 1973-74, 1983-84, 1993-94 and 2003-04 are based on SITC merchandise exports plus services exports (credits). Agricultural exports include beverages (predominantly wine) and sugar. Averages for the three years to 1963-64 are estimates based on a sectoral reallocation of 21 ABS statistical classes published prior to the introduction of SITC (for which data were first introduced for 1969-70). Although not identical, these data are sufficiently close to provide a reasonably accurate picture of the change in agriculture's share of total exports.

Sources: ABS (Cat. no. 5302.0), ABS (Yearbook 1965).

Most of the long-run decline in agriculture's export share has been due to sustained higher growth in other industries. Although agricultural exports have grown in real terms at a trend annual rate of 3.5 per cent since 1974-75, total goods and services exports have grown at almost twice this rate (6.3 per cent a year).[5] And, while price effects also contributed to the decline in share, almost three-quarters of the decline in the agricultural sector's share over the period was due to slower growth in volume terms.

Stronger growth in manufacturing and mining exports have helped transform Australian merchandise exports from a largely agricultural base into a mix of mining, manufacturing and agriculture (table 4.1). This, coupled with strong growth in service exports has resulted in Australia's export profile being split into four roughly equal sized sectoral shares on the broader commodity basis (figure 4.1 above). As a result, changes in a few key commodity prices no longer have the same impact on the Australian economy that they did in previous decades.[6]

5 Longest available constant price SITC time series.

6 For example, in the late-1950s a single commodity, wool, accounted for almost half of Australian export revenue. Wool accounted for 46.1 per cent of total Australian merchandise exports in the three years to 1957-58. However, it fell sharply over the next decade to 26.9 per cent in the three years to 1967-68 (Harris 1990).

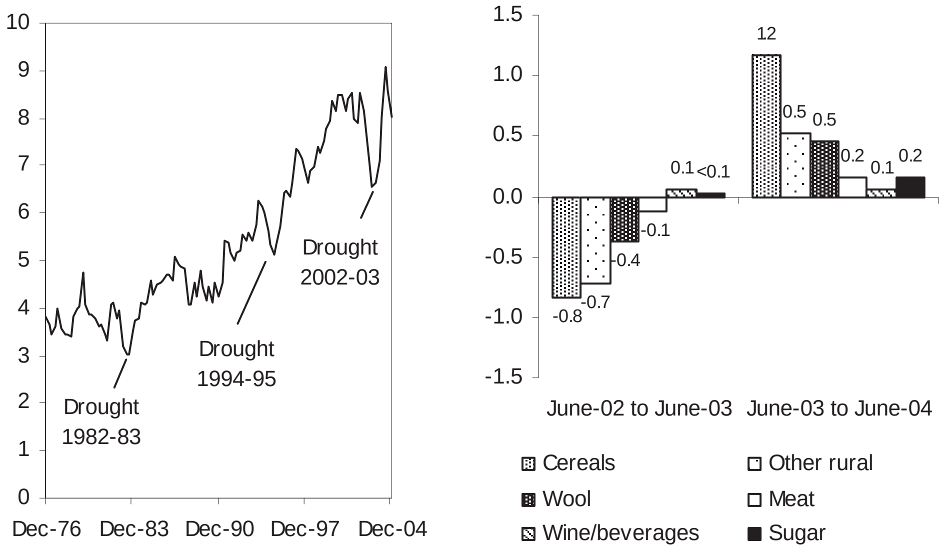
Box 4.1 **Impact of the 2002-03 drought on agricultural exports**

Droughts have traditionally had a substantial impact on Australia's agricultural exports. Quarterly seasonally adjusted data indicate peak to trough falls of 27 and 18 per cent in agricultural export volumes (BOP basis) in the droughts of the early 1980s and mid-1990s (figure 4.2). The 2002-03 drought also had a substantial impact on agricultural exports. Between the June quarter 2002 and the June quarter 2003, export volumes fell by 23 per cent (or $2 billion). The largest contributor to this fall was cereal grains and cereal preparations, with a fall in export volumes of 49 per cent or $844 million over the period. The other contributors were other rural exports, which declined 22 per cent or $725 million, wool and sheepskins (down 35 per cent or $365 million) and meat products (down 8 per cent or $118 million). These declines were only partially offset by slight increases in exports of wine and beverages ($65 million) and sugar ($23 million).

As with earlier droughts, recovery was rapid with increases in export volumes of almost 40 per cent ($2.5 billion) between the trough in the June quarter of 2003 and the June quarter 2004. A more than doubling in cereals exports accounted for almost half ($1.2 billion) of this increase, followed by other rural (up 20 per cent or $522 million), wool (up 67 per cent or $463 million) meat (up 12 per cent or $156 million), sugar (up 45 per cent or $154 million) and wine and beverages (up 8 per cent or $52 million). Consistent with production trends discussed in chapter 2, latest export data indicate that agricultural exports have been declining over the course of 2004-05 — with a 10 per cent fall between the peak in the June quarter 2004 and the December quarter 2004.

Figure 4.2 **Impact of the 2002-03 drought on agricultural exports**

$ billion, constant 2002-03 prices (quarterly, seasonally adjusted)



Source: ABS (Cat. no. 5302.0).

Although agriculture's share of Australian merchandise exports has more than halved over the past four decades, the sector has become even more export oriented. As ABARE (Andrews et al. 2003, p. 250) note:

> Agricultural production has been generally increasing in Australia, primarily as a result of productivity gains. … In contrast, domestic consumption of many agricultural commodities in Australia has either not kept pace with output increases (for example, sugar and wheat) or has shown little if any growth (for example, beef and butter). As a consequence, Australia's agricultural industries have generally become heavily export dependent.

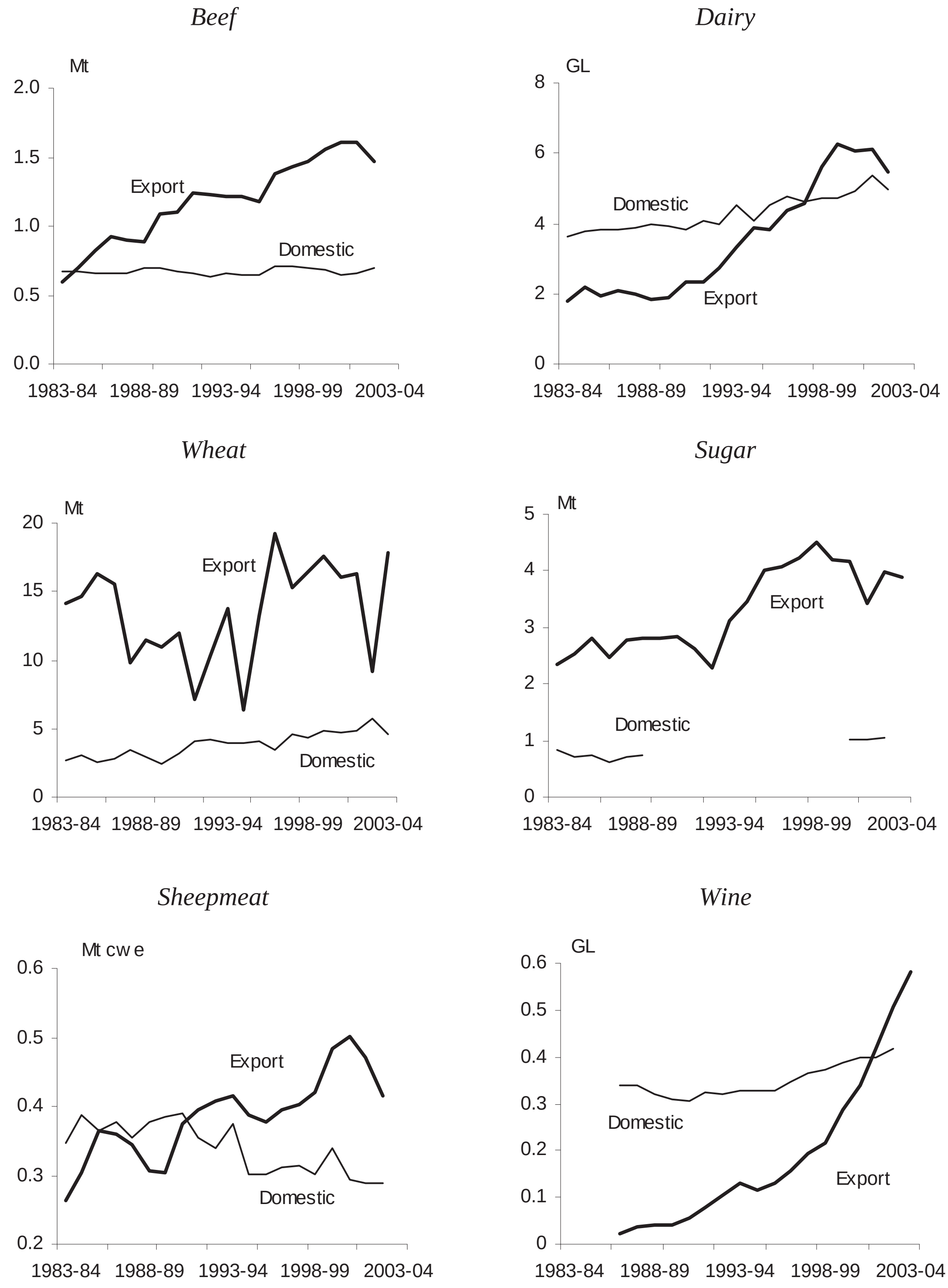
For example, the wool industry currently exports around 95 per cent of its production. The beef, sugar and wheat industries export around 65–75 per cent of production and the sheep meat, wine and dairy industries around 50–60 per cent. With the exception of the wool industry — which has always been highly export oriented — these shares have all risen steadily in recent decades (figure 4.3). Overall, almost two-thirds of agricultural production is now either directly or indirectly exported (DAFF 2005).

Australia, in 2002, was the sixth largest exporter of agricultural products, after the European Union, the United States, Canada, Brazil and China. In the same year, it accounted for 2.9 per cent of world agricultural exports (current prices, $US). Looking at all merchandise exports (excluding service exports), Australia was the 16th largest exporter in the same year, with around 1 per cent of world merchandise exports.[7]

In 2002, Australia accounted for 65 per cent of global wool exports, 25 per cent of mutton and lamb exports, 15 per cent of wheat exports, 9 per cent of wine exports and 3 per cent of sugar exports. Australia is also the world's largest beef exporter, contributing 15 per cent of global beef exports, despite producing only 4 per cent of the world's beef supply (FAOSTAT 2004, DFAT 2003).

[7] Rankings exclude intra-EU trade (WTO 2003).

Figure 4.3 **Australian domestic and export markets for selected commodities, 1983-84 to 2003-04**

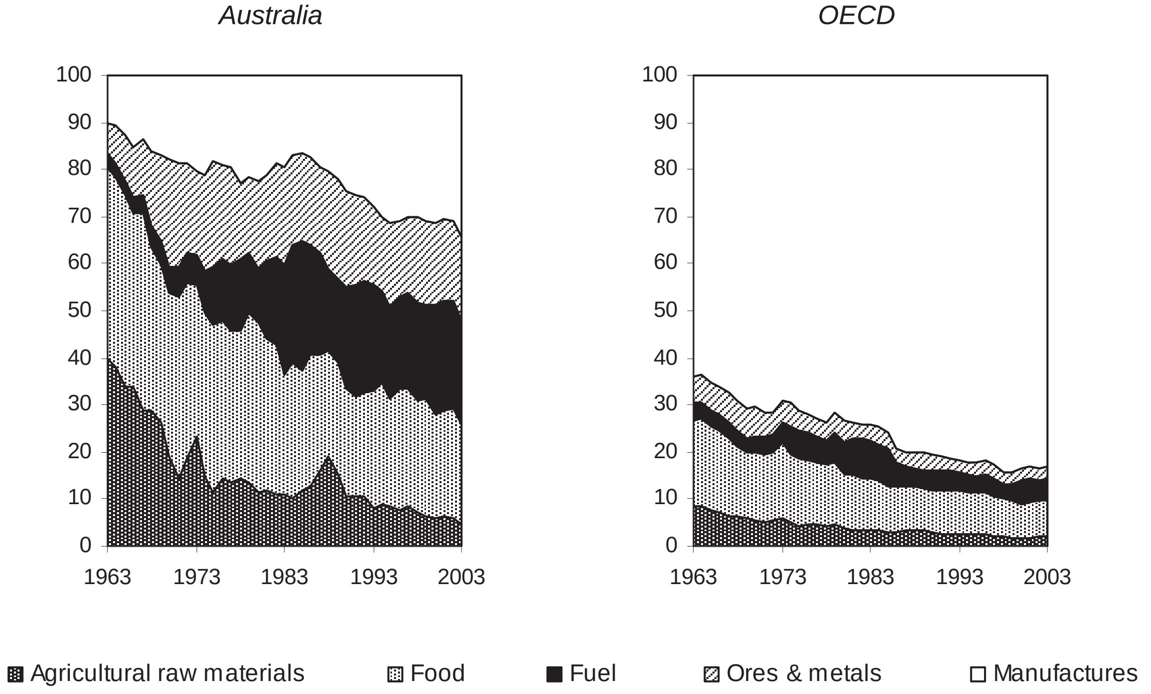


Data sources: Australian Commodities, (vol. 11, no. 1, March quarter 2004, figure E, p. 152) and unpublished ABARE data.

Comparison with other countries

Despite the substantial compositional changes to Australia's trade profile in recent decades, it continues to exhibit a much more resource-based export profile than is the norm for high-income industrialised countries. The 30 per cent share of Australia's merchandise[8] exports contributed by agriculture contrasts with an OECD merchandise export share of less than 10 per cent in 2003 (figure 4.4).

Figure 4.4 **Sectoral shares[a] of total Australian and OECD merchandise exports, 1963 to 2003**
Per cent



[a] Data are based on World Bank aggregations of SITC commodities. Sectoral shares are broadly commensurate with Australian data presented earlier. OECD countries included in these estimates comprise: Australia, Austria, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States.

Data source: World Bank World Tables from Econdata (2005).

In contrast, Australia's industrial profile is broadly comparable to OECD countries, with agriculture accounting for less than 5 per cent of output and employment. But, the fact remains, that Australia has a much greater reliance on the agriculture and mining sectors to generate export revenue than most high-income countries. However, inter-country differences in industry structure and export profiles reflect a

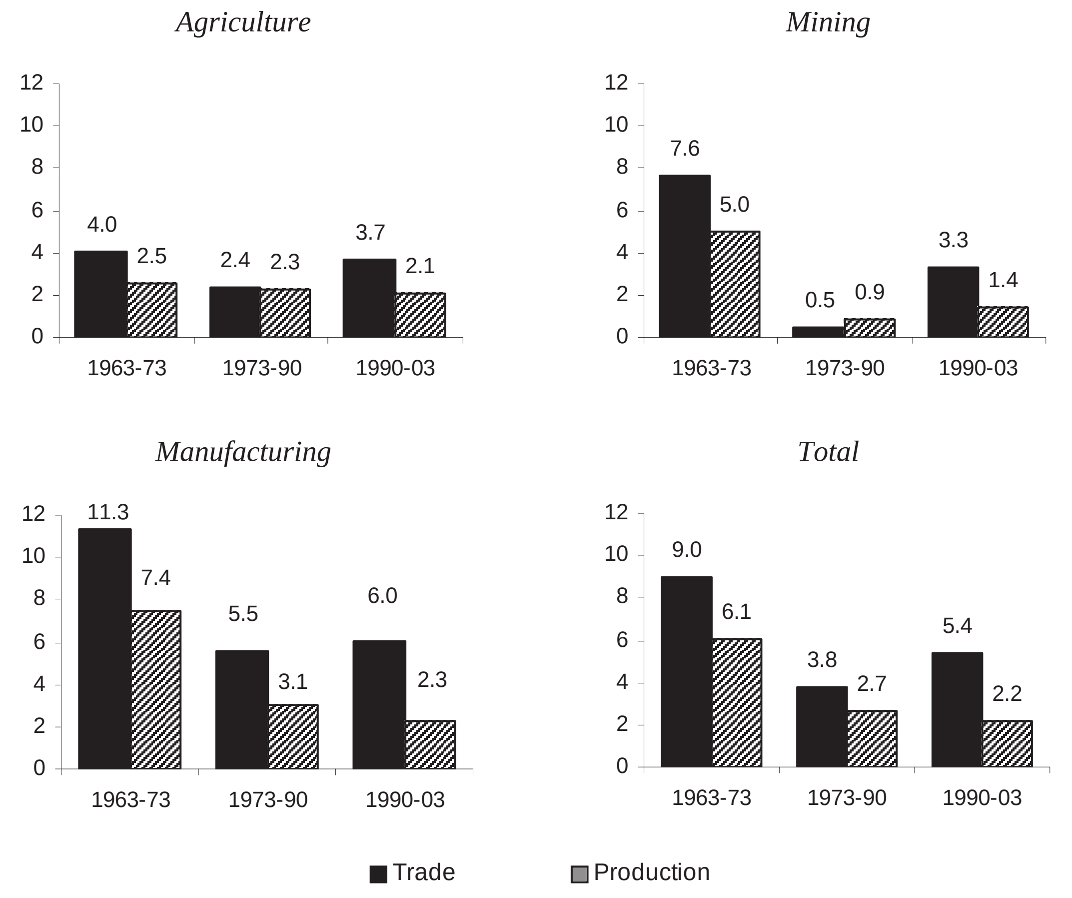
8 Services credits are excluded due to difficulties in obtaining consistent international data.

myriad of factors, including natural resource endowments, divergent historical experiences, proximity to markets, differing impacts of technological advances and cultural and social factors. It does not necessarily follow therefore that Australia's greater reliance on the agricultural and mining sectors as a source of export revenue points to a structural weakness compared to other developed economies.

Australia's greater reliance on these exports provides it with a different set of threats and opportunities to other OECD countries. For example, global agricultural exports have been rising faster than global agricultural production over the past four decades (figure 4.5).

Figure 4.5 **Growth in global production and trade by sector, 1963 to 2003**

Average annual percentage change in volume terms



Data source: WTO (International Trade Statistics 2004).

Since 1990, the volume of global trade in agricultural commodities has increased by 3.7 per cent a year while global agricultural production volumes have increased by only 2.1 per cent a year. But despite this export growth, the share of global merchandise trade accounted for by agriculture continued to fall due to faster growth in trade in manufactures — 6 per cent a year in volume terms since 1990.

Between 1990 and 2003, agriculture's share of global merchandise trade fell from 13 per cent to less than 10 per cent. This decline reflects a continuation of a longer term trend that has seen agriculture's global export share decline in each of the past four decades.

In conjunction with these trends, the price of global agricultural exports continues to decline with respect to manufactured goods (WTO 2003). Domestically, this has been reflected in ABARE's Australian farmers' terms of trade index (prices received for farm products divided by prices paid for inputs) which has fallen by almost 2 per cent a year over the past four decades (Roberts et al. 2004).

Given that Australian agricultural producers are essentially price takers on world markets, these price trends have placed additional pressures on the sector. In the face of these pressures agricultural producers have sought further improvements in 'on farm' productivity (discussed in chapter 6), as well as restructuring and diversifying output (and exports), and in some cases modifying the degree of processing of agricultural products prior to export (for example, dairy co-operatives). Exporters have also sought to further develop existing and new export markets. These changes are examined further below.

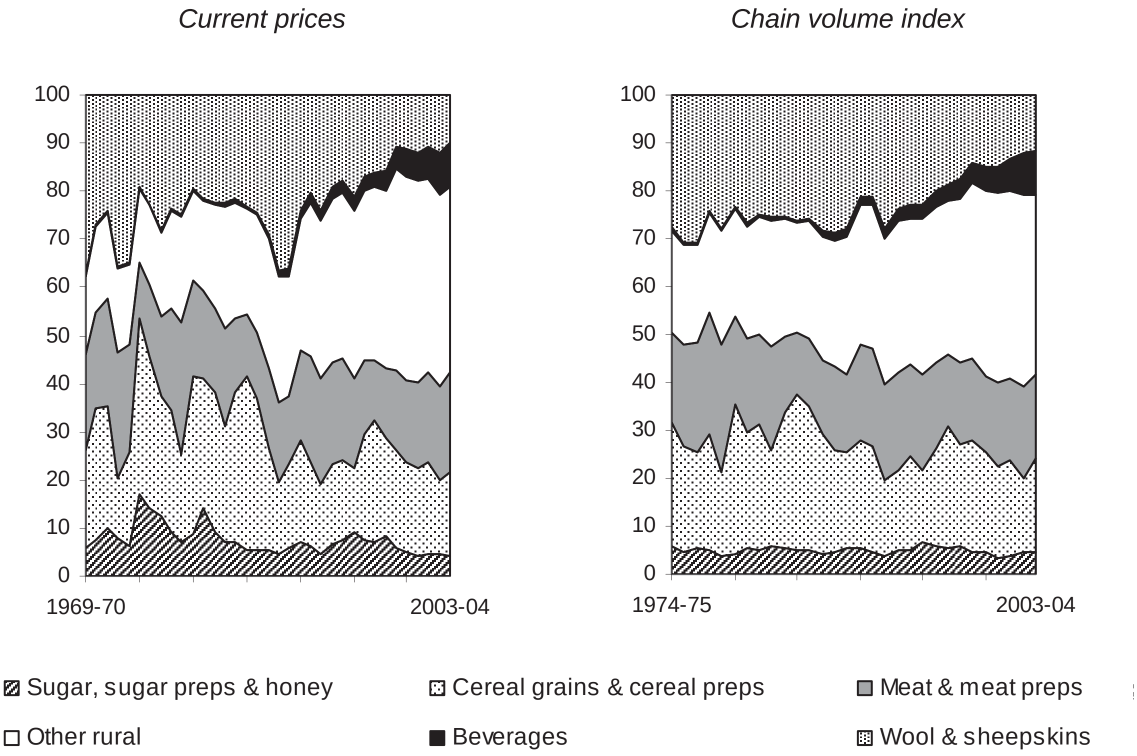
4.3 Key trends within agricultural trade

The changing mix of agricultural exports

The production changes identified in chapter 3, combined with an increase in the processing of agricultural output, have seen the composition of agricultural exports change substantially in recent decades.

Until the late-1960s, a few key commodities dominated agricultural, and indeed Australian exports. In 1969-70, the 'big three' agricultural exports — wool, cereals and meat — accounted for almost four-fifths of agricultural exports in value terms. By 2003-04, their combined share had fallen to just under half (figure 4.6). This reflected the sharp fall in the share of wool and sheepskin exports — from almost 40 per cent of agricultural exports in 1969-70 to 10 per cent in 2003-04. With cereals, meat and sugar retaining roughly similar shares over the period, the 'other rural' category accounted for most of the decline in wool's share. 'Other rural' exports — which include a range of processed foods such as dairy products, tinned and frozen food as well as animal feeds, wood chips and other inedible products — increased from 16 to 39 per cent of agricultural exports over the period. Beverage exports (of which wine comprised 95 per cent of total exports in 2003-04) increased from less than half a per cent in 1969-70 to over 9 per cent in 2003-04.

Figure 4.6 **Agricultural commodity export shares, 1969-70 to 2003-04[a,b]**
Per cent



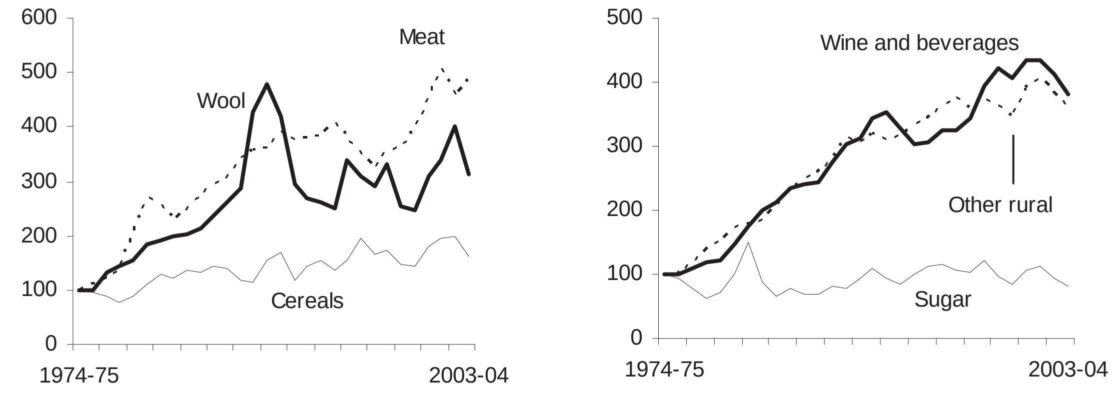
[a] Data are based on the ABS BOP measure 'Rural exports' plus beverages and sugar. This measure is very close to TREC and SITC measures of agricultural exports — $28.3 billion in 2003-04 on a BOP basis compared to $28.2 billion on a TREC basis in the same year (current prices). [b] Current price data are provided for the period 1969-70 to 2003-04. Constant price data are provided for the period 1974-75 to 2003-04 (longest available series).

Data source: ABS (Cat. no. 5302.0).

Changes in commodity prices have affected the contribution of different commodities to total agricultural export values over the period. Between 1974-75 and 2003-04, meat, wine and beverages and 'other rural' recorded the strongest price rises (5.6, 4.7 and 4.5 per cent a year respectively). Wool and cereal grains recorded slower annual price increases (4.0 and 1.6 per cent a year respectively), while sugar prices fell over the period (down 0.8 per cent a year, figure 4.7). In addition, year to year price volatility resulted in sharp changes in shares for particular commodities in some years. For example, a spike in wool prices in 1988-89 saw wool's share of the value of agricultural exports increase by more than 50 per cent, only to fall again as prices dropped back to their previous levels in the early 1990s.[9]

[9] Similarly, a sharp rise in grains prices in 1974-75, combined with a fall in meat prices in the same year resulted in a substantial (albeit short lived) change in these commodities' relative shares of agricultural exports. Sugar prices were also extremely volatile, with sharp rises in the mid-1970s and early 1980s boosting its share briefly (figure 4.7).

Figure 4.7 **Agricultural commodity export prices, 1974-75 to 2003-04**
Index (1974-75 = 100)



Data source: ABS (Cat. no. 5302.0).

Nevertheless, an examination of changes in export volume shares over the past three decades confirms that the long-term trends in compositional shifts identified above are not simply price effects — with broadly similar trends evident in both current and constant prices (figure 4.6).

In real terms (chain volume index, 2002-03 prices), between 1974-75 and 2003-04:

- wine and beverages recorded the highest growth rate (up $2.8 billion — 16 per cent a year), most of which occurred over the past decade or so (box 4.2);
- ‘other rural’ exports recorded the largest overall growth (up $9.2 billion — 6 per cent a year), contributing almost half (46 per cent) of the total growth in agricultural exports;
- sugar exports registered the next highest growth rate (up $750 million — just over 3 per cent a year);
- meat and meat preparations increased by 2.8 per cent a year but contributed 16.8 per cent of overall growth due to the large starting size of the industry;
- cereal grains and preparations increased at 2.5 per cent a year, but accounted for just over 16 per cent of total growth, also reflecting the large starting size of the industry; and
- wool exports increased by less than 1 per cent a year and contributed only 3 per cent of the total growth in agricultural export volumes despite being the largest single export category at the start of the period (table 4.2).

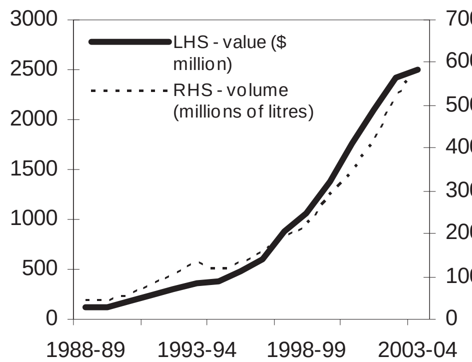
Box 4.2 **Australia's wine exports**

Wine exports are an increasingly important part of our trading profile, with Australia now the fourth largest exporter of wine in the world after France, Italy and Spain. The value of Australian exports has grown from $116 million in 1988-89 to $2.5 billion in 2003-04 — an annual rate of growth of 24 per cent (figure 4.8). This has been underpinned by strong growth in export volumes — up by 20 per cent a year over the past decade and a half, from around 40 million litres in 1988-89 to 581 million litres in 2003-04. Over the same period, exports have increased from less than 5 per cent of total wine sales to more than 50 per cent today. Export values have also benefited from increases in price, with prices per litre up around 3 per cent a year over the past decade and a half. Nevertheless, there has been some volatility. For example, in 2000-01, the average price per litre for exported wine was $5.17, almost twice its value at its lowest point over the past decade and a half (in 1992-93) of $2.85 per litre. A key factor positively affecting the long-term price per litre has been the increasing proportion of Australia's exports made up of bottled wine — with exports increasingly shifting from bulk wine in the 1980s to higher value bottled wine from the early 1990s.

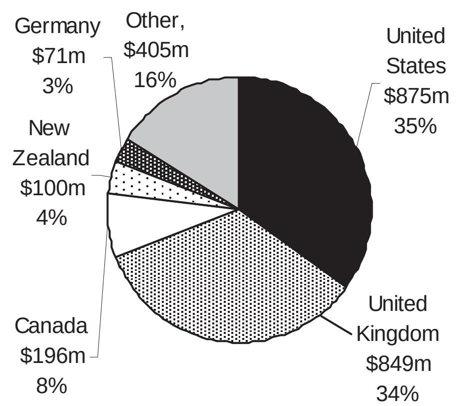
Australia's wine exports are becoming increasingly concentrated among a few key markets. For example, two markets, the United States and the United Kingdom, accounted for almost 70 per cent of all wine exports in 2003-04, up from 40 per cent in 1988-89. Traditionally the United Kingdom has been Australia's largest export market. Although it accounted for more than one-third of total wine exports ($849 million) in 2003-04, the value of exports to the United Kingdom in that year were exceeded for the first time by the United States ($875 million). However, in volume terms, the United Kingdom remains our largest market, accounting for around 20 per cent more exports than the United States.

Figure 4.8 **Wine export growth and patterns of trade, 1988-89 to 2003-04**
$ million, millions of litres

Exports in value and volume terms



Top 5 export markets, 2003-04 (by value)



Sources: DFAT (2004a, STARS Database 2005), Gordon (2005).

Table 4.2 **Trends in rural exports, 1974-75 to 2003-04[a]**

Chain volume index (2002-03 prices), BOP basis[b]

	Level in 1974-75	*Level in 2003-04*	*Total change*	*Trend annual average growth*	*Contribution to growth*
	$ billion			Per cent	
Meat & meat preps	2.1	5.4	3.3	2.8	16.8
Cereal grains & cereal preps	2.8	6.1	3.2	2.5	16.3
Wool & sheepskins	3.0	3.6	0.6	0.7	2.9
Other rural	2.3	11.5	9.2	6.0	46.2
Wine and beverages	0.1	2.9	2.8	15.8	14.0
Sugar, sugar preps & honey	0.6	1.4	0.7	3.1	3.7
Total agriculture	**10.9**	**30.8**	**19.9**	**3.5**	**100.0**

a Longest available constant price series. **b** The BOP measure of 'rural exports' has been modified here by the inclusion of 'non-rural' exports of wine and beverages and sugar to provide a more comparable measure to the SITC and TREC measures used elsewhere in this chapter.

Source: ABS (Cat no. 5368.0).

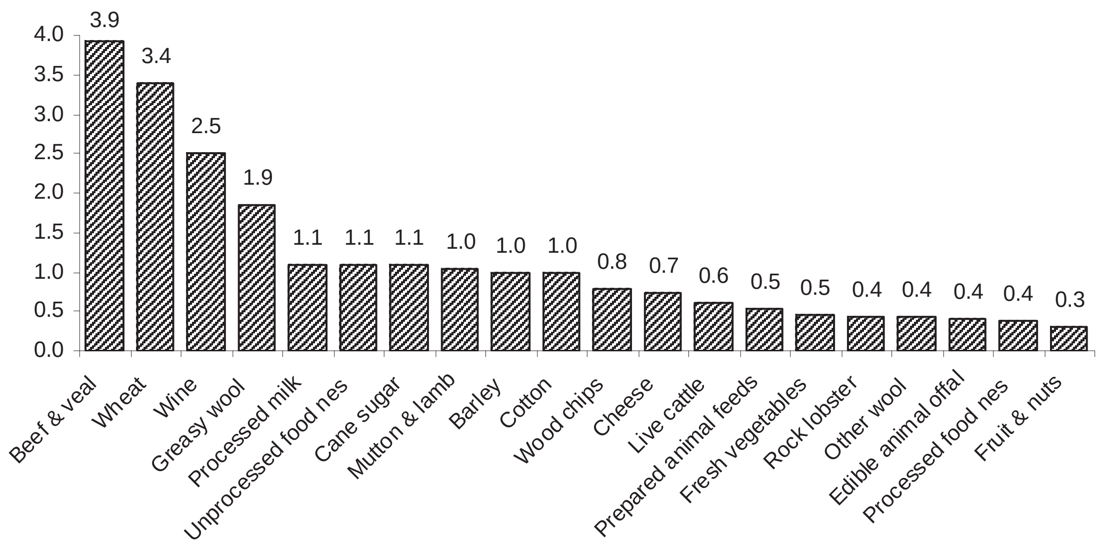
More detailed data available on a TREC basis confirm the increasing diversity of agricultural exports, with a smaller share of total export sales concentrated in a few key commodities. In 2003-04, the top five annual export earners were beef and veal ($3.9 billion), wheat ($3.4 billion), wine ($2.5 billion), wool ($1.9 billion) and processed milk ($1.1 billion), (figure 4.9).[10] Combined, these industries accounted for 45 per cent of total agricultural export sales ($28.2 billion in 2003-04 — current prices). This compares with a figure of 65 per cent for the top five export commodities in 1988-89.

An index of diversification was constructed based on the 99 6-digit TREC agricultural exports commodities.[11] The resulting index provides some evidence of steady, albeit gradual, increases in the diversity of agricultural exports. Between 1988-89 (earliest available year for SITC and TREC data) and 2003-04, the index rose from 0.88 to 0.94 with increases evident in most years.

10 These data are in current prices and hence, differ from data presented for the same year in table 4.2 which are in constant 2002-03 prices and have been adjusted for the 8 per cent fall in agricultural export prices in 2003-04.

11 The resulting index ranges between zero and 1. An index value of 1 indicates exports are completely diversified, with exports spread evenly across all commodities, whereas an index value of zero indicates exports are fully concentrated in a single commodity. The index was calculated as one minus the Herfindahl index (as defined in Bradley and Gans 1998), so that a higher value of the index reflects a higher level of export diversity. The Herfindahl index is calculated as the sum of the square of each commodity's export share.

Figure 4.9 **Top 20 agricultural export commodities, 2003-04**
Annual average exports, $ billion (TREC basis)



Data sources: DFAT (STARS Database 2005) and ABS (Cat. no. 5368.0).

Data on annual average growth rates and commodity contributions to growth since 1990-91 indicate a substantial diversity in the performance of the top 20 agricultural exports (average three years ended 1990-91 compared with average three years ended 2003-04), (figure 4.10). The five largest contributors to overall growth accounted for half of total growth — comprising wine (15 per cent), beef and veal (12 per cent), wheat (10 per cent), processed milk (7 per cent) and unprocessed food (6 per cent).

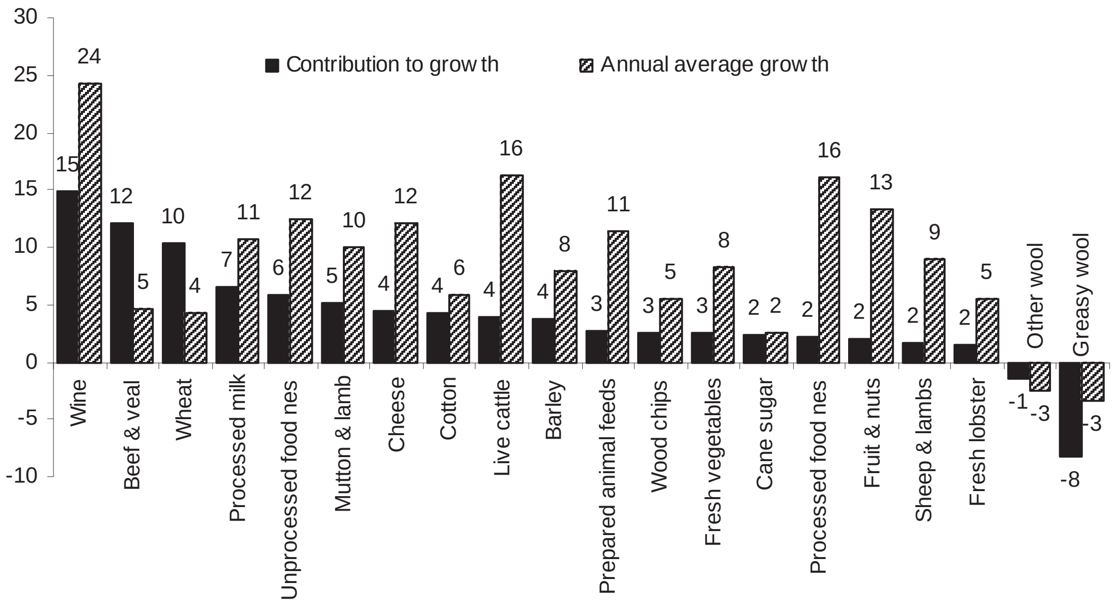
A number of smaller industries also made strong contributions due to high rates of growth: including mutton and lamb, cheese, live animals (predominantly cattle), see box 4.3), prepared animal feeds, processed food (not elsewhere specified) and fruit and nuts. These industries recorded double digit annual growth rates with small, albeit growing, contributions to overall growth. When combined, they accounted for one-fifth of total growth. The only industries to record substantial falls in export values over the period were greasy wool and other wool products, with annual average falls of around 3 per cent in export values.

The compositional changes in agricultural exports identified above have been driven by changes in global demand and supply conditions. Growth in developing countries continues to provide challenges and opportunities for Australian farmers. For example, income growth in developing countries, particularly in Asia, is resulting in rapidly rising per capita consumption levels as well as diet diversification with shifts away from grain-based to livestock-based diets. This has increased demand for Australian agricultural products, notably, for commodities such as meat, seafood and dairy products. At the same time, emerging economies are playing a larger role in supplying world agricultural markets. For example, Argentina and Brazil are major players in the oilseed and beef markets, while Brazil and Mexico are also important suppliers into global sugar markets — all of which means increased competition for Australian farmers on global markets (FAO 2003, OECD 2004a).

For developed countries, factors similar to those driving Australian consumption patterns have been evident (see chapter 3). The OECD projects that demand growth over the next decade in these countries will be driven by shifts in preferences towards products such as poultry, cheese and whole milk powder (appendix B). At the same time, higher projected growth rates in the non-OECD region for all agricultural commodities over the next decade indicate that an increasing share of agricultural produce and feedstuffs will be consumed and produced outside the OECD area (see, for example, OECD 2004a).

Figure 4.10 **Top 20 agricultural export commodities — contribution to growth and growth rate, 1990-91 to 2003-04**

Per cent, current prices (average three years ended)



Data sources: DFAT (STARS Database 2005) and ABS (Cat. no. 5368.0).

Box 4.3 **Australia's exports of live animals**

Australia is a major exporter of live animals, accounting for 33 per cent of global exports of sheep and lambs and 10 per cent of global cattle exports in 2003. The value of Australian live animal exports increased from $296 million in 1988-89 to $865 million in 2003-04 — an annual rate of growth of 7.4 per cent (figure 4.11).

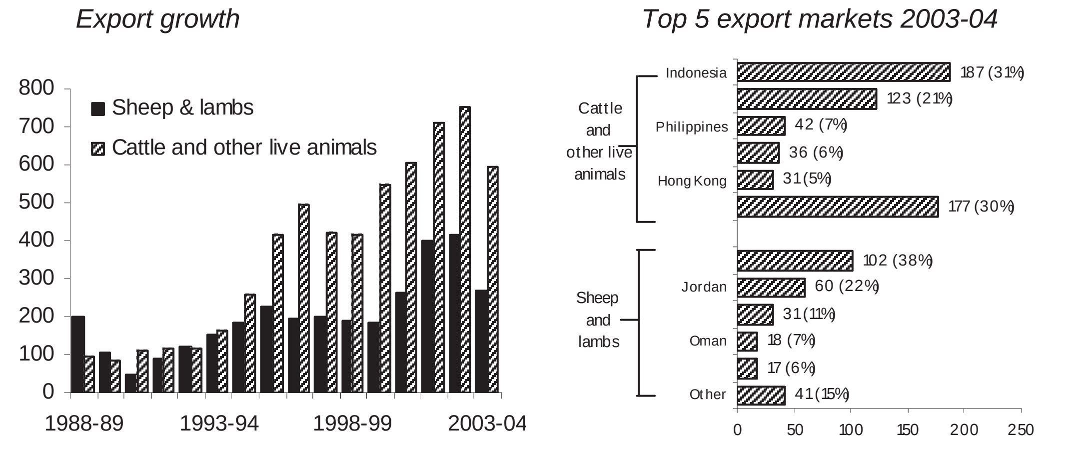
Most of this growth was due to increases in live cattle exports, underpinned by strong growth in cattle export numbers, up 13 per cent a year over the past decade and a half — from 105 000 in 1988-89 to 630 000 in 2003-04. Asia accounts for the majority of live cattle exports. For example, exports of live cattle and other animals (of which cattle comprise around 95 per cent in value terms) to Indonesia (beef cattle predominantly for fattening and slaughtering) and China (diary cattle for breeding) increased by over $300 million — accounting for over 60 per cent of the growth over the period.

Sheep and lamb exports accounted for almost 70 per cent of live animal export values in 1988-89. Despite substantial volatility, overall numbers of sheep exports have declined over the past decade and a half (from 6.4 million in 1988-89 to 3.5 million in 2003-04). Nevertheless, strong price increases have seen export values increase 2 per cent a year (in current prices) over the period.

The Middle East is the predominant market for live sheep and lambs, accounting for 95 per cent of all exports in 2003-04. Strong growth in exports to Kuwait and Jordan in recent years has counteracted the sharp fall in exports due to the recent suspension of trade with Australia's largest market, Saudi Arabia. Most exports are sourced from Western Australia, South Australia and Victoria where a specialised industry has developed to supply the lean male sheep preferred by these markets.

Figure 4.11 **Live cattle and sheep export growth and patterns of trade, 1988-89 to 2003-04**

$million



Sources: DFAT (STARS Database 2005), ABARE (2004d), FAOSTAT (2004), Livecorp (2004).

Imports and intra-industry trade

Imports of agricultural commodities into Australia are relatively small. In 2003-04, they amounted to just under $8 billion, less than one-third of agricultural exports and around 7 per cent of total merchandise imports. Prior to the 1960s, agricultural imports routinely constituted over 10 per cent of Australian merchandise imports. Since then, this share has fallen steadily due largely to the rapid growth in trade in manufactures. Over the same period, the composition of agricultural imports has shifted towards a range of processed foods, including alcoholic beverages, processed and specialty foods such as preserved fruits and vegetables, cereal preparations, seafoods and cheeses.

Some of these agricultural imports constitute two-way trade or intra-industry trade — the export and import of similar products by a country. This form of trade is most commonly associated with manufactured goods. Nevertheless, intra-industry trade in agriculture has risen strongly for developed countries since the 1970s reflecting a range of factors, including:

- increased product differentiation and branding, so that horizontal trade in basically similar products increases (exemplified by the sale of different brands of beers, wines and spirits across borders);
- greater sophistication in the nature of consumer demand;
- a reduction in trade barriers; and
- greater global integration of production (FAO 2003, PC 2003).

The key driver of intra-industry trade in agriculture for any country is the development of a food processing capability. As the Food and Agriculture Organization (FAO) of the United Nations notes (2003, p. 293):

> Growing two-way trade goes hand in hand with the development of an internationally competitive food processing industry.

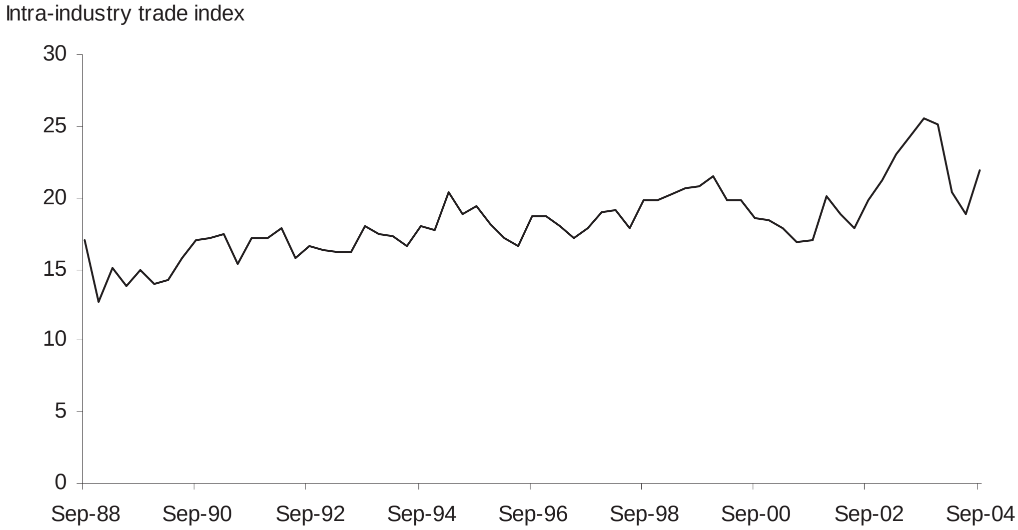
Much of the growth in Australian agricultural exports discussed earlier has been in different types of processed food.[12] Overall, processed food exports increased from 36 per cent of total agricultural exports in 1990-91 to 48 per cent in 2003-04. Over the same period, processed food imports increased from 50 to 62 per cent of total agricultural imports. Consistent with these changes, intra-industry trade in

[12] The category 'Processed foods' is contained within the TREC system and includes edible agricultural products that have been transformed to some degree. Hence, it includes products that have received a low level of processing as well as some involving relatively high levels of processing such as — meat and dairy products, seafood preparations, liquid and dried eggs, refined sugar, fruit and vegetable preparations, prepared animal feeds and alcoholic beverages (DFAT 2004c).

agriculture appears to have been increasing — from a Grubel-Lloyd index[13] estimate of around 15 per cent in 1988-89 to around 20 per cent in 2003-04 (figure 4.12). For an explanation of how the index is constructed see appendix B.

Key contributors to this increase included non-bovine meats, cereal preparations, animal feeds, seafood, fruit and nuts, chocolate, cheese and curd, fruit juices, fresh vegetables and other food products. Combined, these industries accounted for four-fifths of the increase in intra-industry trade over the period.

Figure 4.12 **Intra-industry trade in Australian agriculture[a], 1988 to 2004**
Quarterly data



[a] Estimates are based on trade within the 64 SITC three-digit agricultural categories plus the two-digit category 'Beverages'. As consistent deflators were not available, the index is based on current price data. Hence, caution should be exercised in interpreting movements in the index as the data reflect both volume and price effects.

Data source: DFAT (STARS Database 2005).

13 There are several criticisms of the Grubel-Lloyd index. In particular, the greater the trade imbalance, the smaller will be the share of intra-industry trade (as evident by the increase in the index when exports fell due to the drought of 2002-03. In addition, the level of aggregation employed affects the index values. Even so, alternative measures have problems and the Grubel-Lloyd index remains the measure most commonly applied (Grubel and Lloyd 1975, Dixon and Menon 1995, PC 2003).