



Economic Issues Associated with the South Australian Live Sheep Export Trade



Dr Alistair Davey



Pegasus Economics • www.pegasus-economics.com.au • PO Box 449 Jamison Centre, Macquarie ACT 2614

Pegasus Economics is a boutique economics and public policy consultancy firm that specialises in strategy and policy advice, economic analysis, trade practices, competition policy, regulatory instruments, accounting, financial management and organisation development.

This report has been commissioned by Animals Australia to examine the economic impact arising from the cessation of the live sheep export trade for South Australia.

The views and opinions expressed in this report are those of the author.

For information on this report please contact:

Name: Dr Alistair Davey

Telephone: + 61 2 6100 4090

Mobile: 0422 211 110

Email: adavey@pegasus-economics.com.au

Front cover photograph shows sheep grazing on canola stubble near Gulgong in New South Wales.

Table of Contents

Executive Summary	iv
1 Introduction	1
2 Animal Welfare Issues.....	1
3 Sheep and their Economic Application	2
3.1 Taxonomy of Sheep.....	2
3.2 Economics of Sheep Production	3
4 Australian and South Australian Sheep Flock	4
5 Live Sheep Exports	7
6 Significance of the Live Sheep Export Trade for South Australian Sheep Farmers.....	11
7 Do Live Sheep Exporters Pay a Price Premium?	13
8 Capacity of South Australian Sheep Meat Processors	15
9 Economic Impact from Phasing Out of the Live Sheep Export on South Australia.....	16
10 Significance of Live Sheep Exports to the Overall Sheep Meat Trade	18
11 Conclusions	20
Appendix 1: Estimating Price Impact of the Live Sheep Export Trade on South Australian Sheep Prices	21
Bibliography	24

Figure 1: Australian Sheep Flock Numbers, Australian Wool Production (tonnes) and Lamb Meat Production (cwt tonnes) – 1988 to 2017	5
Figure 2: South Australian Sheep Flock Numbers, South Australian Wool Production (tonnes) and Lamb Meat Production (cwt tonnes) – 1987 to 2017	6
Figure 3: South Australian Sheep Flock Numbers and South Australian Hectares Devoted to Wheat, Barley, Canola and Oats Production – 1987 to 2017	6
Figure 4: Australian Live Sheep Exports – 1988 to 2017 ('000)	8
Figure 5: Western Australian, Victorian, South Australian and New South Wales Monthly Live Sheep Exports – January 2015 to December 2017	9
Figure 6: Monthly South Australian Live Sheep Exports – January 2015 to December 2017.....	10
Figure 7: Annual Live Sheep Export Loadings at Port Adelaide – 1990 to 2017	10
Figure 8: Average Farm Cash Receipts for a South Australian Specialist Sheep Farmer – 1999-2000 to 2015-16	11
Figure 9: Average Adult Sheep Sales and Average Sales of Sheep to Live Sheep Exporters for a South Australian Specialist Sheep Farmer – 1999-2000 to 2015-16	12
Figure 10: Average Farm Cash Receipts for a South Australian Mixed Enterprise Sheep Farmer – 1999-2000 to 2015-16	12
Figure 11: Average Adult Sheep Sales and Average Sales of Sheep to Live Sheep Exporters for a South Australian Mixed Enterprise Sheep Farmer – 1999-2000 to 2015-16.....	13
Figure 12: New South Wales, Victorian and South Australian Mutton Saleyard Indicator for Mutton (cents per kilogram (c/kg) carcase weight (cwt)) – 16 December 2014 to 14 December 2017	14
Figure 13: South Australian Slaughtering of Lamb, Mutton and Sheep – 1987 to 2017 (000').....	16

Figure 14: Carcase Equivalent Exports of South Australian Mutton, Lamb and Processed Sheep Meat and Live Sheep Exports Loaded at Port Adelaide – 2007 to 2017	19
Figure 15: Estimated Value of South Australian Mutton, Lamb, Processed Sheep Meat and Live Sheep Exports – 2008-09 to 2016-17 (\$ million)*	19
Table 1: Estimated Processing Capacity of SA abattoirs to Slaughter Sheep per week.....	15
Table 2: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test with two specifications	22
Table 3: DOLS regression for equations (1), (2) and (3) (HAC t-statistic probabilities in brackets)	23

Executive Summary

- The Middle East region is the largest destination for Australian live sheep exports (Deards, et al., 2014, p. 22). However, the trade has a documented history of large-scale animal suffering (Bruce, 2012, p. 292).
- Rather than being a market for sheep in general, the live sheep export trade is primarily a trade in heavy wethers.¹
- Australia's live sheep export trade has been in trend decline since the 1980s.
 - Although live sheep exports have more recently peaked at over 6 million per annum during 2001 and 2002, they have been in fairly continuous decline since then, falling to below 2 million per annum since 2014.
- The Australian live sheep export trade has been predominantly comprised of sheep sourced from Western Australia. Since the beginning of 2015, live sheep sourced from Western Australia have made up around 88 per cent of the Australian live sheep export trade by volume, with South Australia (SA) making up only 10 per cent by volume.
 - When the supply of wethers in Western Australia is sufficient, voyages to the Middle East are usually loaded in Fremantle (Deards, et al., 2014, p. 53). It takes less time to reach the Middle East from Fremantle than Port Adelaide or Portland and the voyage is therefore less costly.
 - Where consignments cannot be filled in Western Australia, or sheep can be purchased at sufficiently less cost elsewhere, exporters may purchase and load sheep from other states, now most commonly South Australia with the decline of Portland in Victoria as a loading port for the live sheep export trade.
- Since the beginning of 2015, 91 per cent of live sheep exports from South Australia have been exported through ships loaded from the Common User Berth in the Inner Harbour at Port Adelaide. The remaining 9 per cent are transported via air freight from Adelaide Airport.
- Similar to the Australian live sheep export trade overall, live sheep exports from South Australia have substantially declined since the early 2000's when annual loadings from Port Adelaide peaked in excess of 1.3 million during 2001 and 2002 and in 2017 it was less than 260,000.
- With the decline of the live sheep export trade, the relative significance of the trade for SA sheep farmers has also diminished.
 - Although the relative significance of sheep sales for SA sheep farmers in terms of its contribution to total farm cash receipts has increased since 1999-2000 for both specialist sheep farmers and SA mixed enterprise sheep farms, the relative contribution of the live sheep export trade to sheep sales in terms of volume has significantly reduced.
- Unlike the case for Western Australia where there is evidence of a price premium paid by live sheep exporters to procure sheep compared to other purchasers that dissipates with the quality of the sheep, the available evidence strongly suggests there is no price premium being paid by live sheep exporters to SA sheep farmers.
 - Consultations with parties involved in sheep purchasing in South Australia suggest that live sheep exporters focus primarily on procuring sheep that are lighter and of

¹ Castrated male sheep with no 'ram-like' characteristics and with more than two permanent adult teeth (Meat & Livestock Australia Limited, 2016) that are typically aged between one and two years (Deards, et al., 2014, p. 9)

lower quality, and do not compete against sheep meat processors to procure heavier and higher quality sheep. The views of these parties were that live sheep exporters had little price impact on SA sheep prices.

- On current utilisation levels, the SA meat processing industry has sufficient spare capacity to absorb the entire quantum of live sheep exported annually from South Australia and still have spare capacity to process almost another 1.2 million sheep per annum.
- In the absence of any evidence suggesting there is a price premium being paid by live sheep exporters to South Australian sheep farmers to procure stock, there would appear to be very little downside for the South Australian economy from the cessation of the trade. In fact, the cessation of the live sheep export trade would provide a small fillip to the South Australian economy through further value adding by meat processors.
- The cessation of the live sheep export trade will have a positive material impact on SA sheep meat processors.
- The live sheep export trade to the Middle East and the subsequent processing of Australian sheep meat in the region, cannibalises domestically processed sheep meat exports from Australia that competes against it. Thus, live sheep exports also result in the export of meat processing and the associated employment and income generated overseas.
- The phasing out of the live sheep export trade will provide SA sheep meat processors with the opportunity to engage in further value adding activities.
 - Meat processors ‘add value’ by transforming livestock into meat and other co-products (Industry Commission, 1994, p. 240).
- The cessation of the live sheep export trade will provide for the redirection of some sheep to domestic processors that in turn will enable them to raise their capacity utilisation and employment levels.
 - It would also improve economies of scale in meat processing, making processed sheep meat products more price competitive.
 - An increase in employment due to the engagement of unemployed and/or underemployed people will generate higher economic growth and a reduction in unemployment benefits coupled with a reduced financial impost on taxpayers.
- Live sheep exports loaded from Port Adelaide have been the least significant component of South Australia’s sheep meat exports in volume terms since 2004 when carcase equivalent mutton exports surpassed live sheep exports.² In 2017, South Australia exported over 10 times the volume of carcase equivalent processed sheep meat than live sheep exports loaded from Port Adelaide.
- The value of processed sheep meat exports from South Australia of around \$500 million in 2016-17 was in excess of 20 times the value of live sheep exports from South Australia of around \$23 million in 2016-17.
- The significance of the live sheep export trade for SA sheep farmers has substantially diminished since the early 2000s. Furthermore, there is no evidence to suggest that SA sheep farmers would be worse off in the event of the cessation of the live sheep export trade.
- The cessation of the live sheep export trade will provide a positive material benefit to the SA sheep meat processor sector enabling it to engage in further value added processing rather

² The one exception to this is live sheep exports air freighted from Adelaide Airport although this is a fairly recent phenomenon and relatively small component of the overall live sheep export trade and will not be considered further for the purposes of this comparison.

than seeing the value added processing exported overseas through the live sheep export trade.

1 Introduction

This report has been commissioned by Animals Australia to examine the economic impact associated with the cessation of the live sheep export trade from South Australia (SA).

2 Animal Welfare Issues

The Middle East region is the largest destination for Australian live sheep exports (Deards, et al., 2014, p. 22). However, the trade has a documented history of large-scale animal suffering (Bruce, 2012, p. 292).

A study on the main causes of mortality in live sheep onboard livestock vessels published by Meat & Livestock Australia (MLA) found that salmonella induced enteritis was the most common cause of mortality (34.4 per cent), followed by inanition (23.9 per cent), enteritis/inanition (18.2 per cent) and 9.5 per cent for heat stress (Makin, House, Perkins, & Curran, 2010).³

Conditions on live export shipments regularly expose sheep to heat stress, which appears to be most severe for sheep transported from Australian winters to summer in the Middle East (Phillips, 2016, p. 84). The contributing factors to heat stress in the export of livestock from Australia in winter to the Middle East in summer are:

- high temperature and humidity; reduced variation in circadian temperature;
- high stocking densities which increase heat production and limit opportunities for sheep to mitigate heat load effects;
- the presence of excreta; and
- variable ventilation rates.

Sheep being shipped by sea from southern Australia to the Middle East endure journeys lasting up to 3 weeks (sometimes longer if there are visits to multiple ports at both ends, called ‘split voyages’). In the past, high mortalities have been associated with the export of stock from Portland in Victoria and Port Adelaide during winter (Farmer, 2011, p. 8). Several factors contributed to these rates including poor sourcing, selection and preparation of stock at the feedlot, harsh climatic conditions combined with the lack of adequate shelter. These factors were compounded with rough and cold conditions experienced on the journey across the Great Australian Bight.

Several independent reviews commissioned by the Australian Government have called for these ‘high risk’ exports from Portland and Adelaide to be reconsidered. The 2003 Livestock Export Review chaired by Dr John Keniry (Keniry, Bond, Caple, Gosse, & Rogers, 2003, p. 42) suggested that in order to better manage heat stress in live sheep export shipments there should be a prohibition on exports from areas such as Portland and Adelaide during periods of the year that the risks are greatest, principally May-October inclusive. However, this recommendation was not accepted by the Australian Government (Farmer, 2011, p. 51). Similarly, the 2011 Independent Review into Australia’s livestock export trade undertaken by Bill Farmer (2011, p. 59) observed:

[The Australian Quarantine and Inspection Service] has made the point that split voyages from southern ports, for example involving loading at Portland or Adelaide and Fremantle, often strike extreme weather conditions in the Great

³ Enteritis causes the swelling or inflammation of the small intestine (Fitzgibbon, 2015). Inanition is an exhausted state of prolonged under nutrition or starvation (Blood & Studdert, 1999).

Australian Bight and the rough trip and longer port time can result in higher shipboard losses.

Recommendation 6 from Farmer Review (2011, p. XXV) was for a comprehensive review of the Australian standards for the export of livestock (ASEL) to be undertaken including an examination of the policy on export of sheep from southern ports to the Middle East in winter months, with a view to:

- mitigate feedlot and shipboard losses in adverse weather conditions; and
- mitigate losses from heat stress and inanition during the voyage.

One review of the ASEL was completed in 2013 although there was a lack of consensus on the part of the ASEL Steering Committee established on the policy of exporting sheep from southern ports to the Middle East in winter months and hence no recommendation was made on the matter (Department of Agriculture, Fisheries and Forestry, 2013, p. 16). Another review of the ASEL is currently underway. Despite the reviews, several high mortality voyages have since occurred, including the worst in August 2013 when the mortality rate of sheep loaded at Port Adelaide was 7.28 per cent (3,256 out of 44,713 sheep loaded) mainly from heat stress on a 23 day voyage to the Middle East (on the Bader III) and other sheep loaded at Fremantle also died (Department of Agriculture, 2014). The sheep from Port Adelaide first encountered 'rough sea' in the Great Australian Bight and temperatures as low as 12 on the sheep decks, before enduring heat and humidity from the equator to their final destination ports in the Middle East (up to a wet-bulb temperature of 38 degrees).

Over the years, evidence has also indicated that the suffering experienced by sheep does not stop with the transport ships (Bruce, 2012, p. 293). Sheep are housed in feedlots awaiting slaughter and in summer months temperatures and humidity can be extreme. Sheep exported to Persian Gulf countries are slaughtered while fully conscious.

3 Sheep and their Economic Application

3.1 Taxonomy of Sheep

Sheep can be categorised on the basis of sex and age (measured in terms of the number of adult teeth they possess on their lower front jaw). When born, sheep usually have no teeth (Cashburn, 2016). Within a week after birth, the milk teeth or temporary teeth appear in the front lower jaw and by the time the sheep is two months old these, eight in all, have erupted. These temporary teeth are eventually replaced by permanent incisors or adult teeth, which appear in pairs, commencing with the two central teeth, followed by one on either side at intervals, until the eight temporary teeth have been replaced. During the period the teeth are growing, sheep are referred to by the number of permanent incisors present, such as two-tooth, four-tooth, six-tooth, eight-tooth or full mouth. Sheep will usually be over two before they are six-tooth, and at least three before they are full mouth.

As sheep age, the adult teeth will start to spread, wear and eventually break (Schoenian, 2015). This progressive deterioration is known as 'broken mouth', the rate depending on the conditions under which the sheep has grazed (Cashburn, 2016).

Sheep can be divided into the following categories:

- Very young male and female sheep that are still sucking are referred to as young lamb (Meat & Livestock Australia Limited, 2016).

- Young male and female sheep that have been weaned, normally older than 5 months and typically under 14 months with no permanent adult teeth are referred to as lamb (Meat & Livestock Australia Limited, 2016; Jones, 2004, p. 1).
- Hoggets are castrated male and female sheep with no 'ram-like' characteristics and up to two permanent adult teeth (Meat & Livestock Australia Limited, 2016).
- Ewes are female sheep with more than two permanent adult teeth (Meat & Livestock Australia Limited, 2016).
- Wethers are castrated male sheep with no 'ram-like' characteristics and with more than two permanent adult teeth (Meat & Livestock Australia Limited, 2016).
- Rams are male sheep that have not been castrated and castrated male sheep that display 'ram-like' characteristics such as aggressive behaviour such as head butting.

3.2 Economics of Sheep Production

Sheep are farmed throughout the world, with most production constrained by temperature and rainfall to islands, coastal regions and the fringes of continental deserts (Sargison, 2008, p. 451). In some regions sheep are used to exploit pastures which are unsuitable for other agricultural purposes, while elsewhere sheep production is integrated into other agricultural systems to enable cost-effective and efficient grassland management or crop rotation.

In Australia, sheep farming is mostly concentrated around the wheat-sheep and high rainfall zones in New South Wales, Victoria, Western Australia and South Australia. Around half of Australia's sheep are located in the wheat-sheep zone where they are grazed on sown pasture in rotation with cereal crops (Australian Surveying and Land Information Group, 1990, p. 44). The high rainfall zones lie along the wetter, coastal side of the wheat-sheep belt, where the natural pastures are rich, and carry around one third of sheep. The inland pastoral zone lies on the drier, inland side of the wheat-sheep belt and carries around 20 per cent of sheep.

Sheep give rise to four products, namely:

- wool;
- sheep meat;
- skin; and
- milk.

Wool and sheep meat are the primary outputs from sheep farming, with market conditions for each commodity affecting the size and composition of the national sheep flock (Deards, et al., 2014, p. 6). Historically, the sheep meat industry has developed as a by-product of the wool industry (Jones, 2004, p. 1). Although the use of wool in textiles has faced major competition from synthetic fibres, world wool production is relatively stable at just over 2 million tonnes (Sargison, 2008, p. 451). Sheep are inferior as convertors of their feed to meat relative to poultry and pigs, largely because of the overhead costs of breeding stock and replacements, however, they can live and produce on land unfavourable to other forms of agriculture (Morris, 2009, p. 59).

Sheep skins are often considered a by-product of the sheep meat manufacturing process (Sargison, 2008, p. 451). While there are more sheep milked each day than cattle worldwide, sheep dairying is a relatively small industry in Australia (Biosecurity Tasmania, 2014, p. 1). Most sheep milk is primarily used in the manufacture of cheese (Sargison, 2008, p. 451).

Sheep meat produced from young sheep with no permanent adult teeth is referred to as lamb while sheep meat produced from more mature sheep (with at least one adult tooth) is referred to as

mutton. The colour of lamb meat ranges from pale pink to pale red and is generally lean while its mild flavour makes it very versatile for a number of uses (Prakash, 2016). On the other hand, mutton has a deep red colour and is much fattier than lamb; its flavour is strong and gamey and the meat is often stewed to help tenderise it (Prakash, 2016). Mutton can have a distinctive odour and flavour that can be unattractive to consumers (Sheep CRC, 2008). Mutton typically attracts a lower price than lamb due to age, fat content, flavour, and eating quality (Meat & Livestock Australia, 2016b).

4 Australian and South Australian Sheep Flock

The Australian sheep industry was initially founded on wool production from Spanish (Merino) sheep (Keogh, Henry, & Day, 2016, p. 38) that provided the economic impulse that opened up the Australian continent (Harman, 1971, p. 41). Up until the early 1960s, wool was one of Australia's most important primary product exports, and in the popular mythology of previous generations Australians perceived their economy as having been dependent on wool exports for much of its existence (Cashin & McDermott, 2002, p. 249); hence the old expression that "Australia is riding on the sheep's back."

The Australian sheep flock, currently at around 70.2 million (Australian Bureau of Statistics, 2018b), is the second largest in the world following mainland China with 162 million sheep in 2016.⁴ The Australian sheep flock has peaked twice at 170 million in 1965 and again in 1990 (Australian Bureau of Statistics, 2013). The development of synthetic fibres in the years following the Second World War created growing competition and declining prices for Australian wool (Keogh, Henry, & Day, 2016, p. 38).

Wool produced has usually been sold at auction that traditionally operated as a free market of buyers and sellers (Michalk, 1990, p. 190). However, that changed with the establishment of the Reserve Price Scheme (RPS). The RPS was a buffer stock scheme designed to maintain minimum prices – the so-called Minimum Reserve Price (MRP) – for wool sold at auction, that was established in November 1970 (Haszler, 1994, p. 87). Under the RPS, the Australian wool industry paid a 'Wool Tax' on production, with the proceeds accumulating in a Market Support Fund that was used to finance buffer stock operations by the Australian Wool Corporation (AWC) (Bardsley, 1994, p. 1088).

Under the buffer stock operations, the AWC bought up wool offered at auction that failed to reach the reserve price in order to protect wool growers against unduly low prices resulting from temporary irregularities in demand at auction (Michalk, 1990, p. 190). When the Market Support Fund was exhausted buffer stock purchases were financed by commercial borrowing against the security of the stockpile accumulated by the AWC (Bardsley, 1994, p. 1088).

In 1987 Australian Government control over the scheme was reduced and the power to set the MRP was substantially delegated to Australian wool grower representatives (Bardsley, 1994, p. 1088). The price of wool soared following a run-down of stocks in 1987, and the MRP set by the industry followed it up. The AWC then embarked on a massive program of price support. Accumulated grower funds were subsequently exhausted and the AWC borrowed to the limit of its capacity against the security of the stockpile (Bardsley, 1994, pp. 1088-1089).

In January 1991, the Australian Government announced the suspension (and later the abandonment) of the RPS that in turn triggered a wool price collapse, leaving the Australian wool

⁴ The estimate of the Chinese sheep flock comes from the United Nations FAOSTAT database.

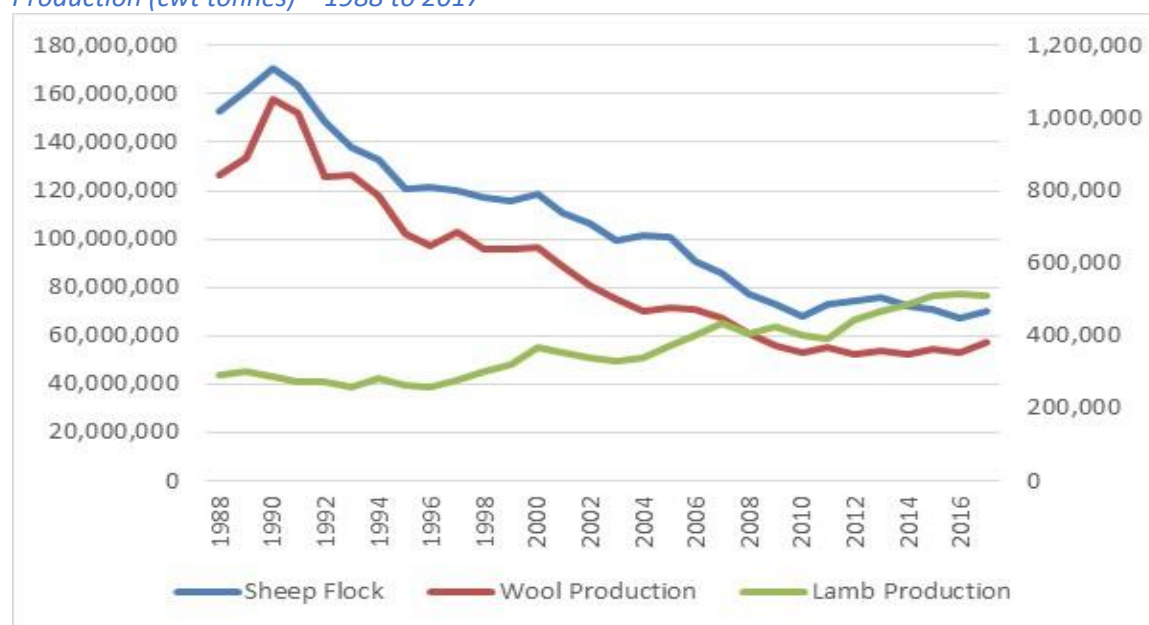
industry with a stockpile of 4-6 million bales of wool (almost one year's normal production) and a debt of \$2 7 billion (Bardsley, 1994, p. 1087).

The Australian sheep flock has fallen considerably from its most recent peak of 170 million in 1990 precipitated by the collapse of wool prices and the RPS that in turn ushered in a period of structural adjustment that manifested itself in a number of ways. Overall, the number of sheep and farms carrying sheep declined (Australian Bureau of Agricultural and Resources Economics, 2004). The fall in wool prices, coupled with rising grain prices, saw a shift towards cropping by many farms and an expansion of cropping in more marginal areas (Dahl, Leith, & Gray, 2013, p. 207). The decline in wool production was much greater than the fall in sheep numbers, reflecting the creation of a younger flock structure driven by a move towards lamb production (Australian Bureau of Agricultural and Resources Economics, 2004). The focus on lamb production contributed to a decline in the number of wethers in the Australian sheep flock and a concurrent increase in the proportion of ewes required for lamb production (Chow, K, 2013).

Similar to the Australian sheep flock overall, the SA sheep flock fell from its most recent peak of 18.4 million in 1990 to just under 9 million in 2010, a fall of over 50 per cent.⁵ Since 2011, however, the SA sheep flock has stabilised at around 11 million.⁶

The fairly close relationship between sheep flock numbers and wool production and the inverse relationship with lamb production are outlined for Australia in Figure 1 and for South Australia in Figure 2 below. SA wool production tracks the decline in sheep numbers reasonably closely up until 2001, after which time there is a significant drop-off in wool production coupled with a ratcheting up of lamb production.

Figure 1: Australian Sheep Flock Numbers, Australian Wool Production (tonnes) and Lamb Meat Production (cwt tonnes) – 1988 to 2017

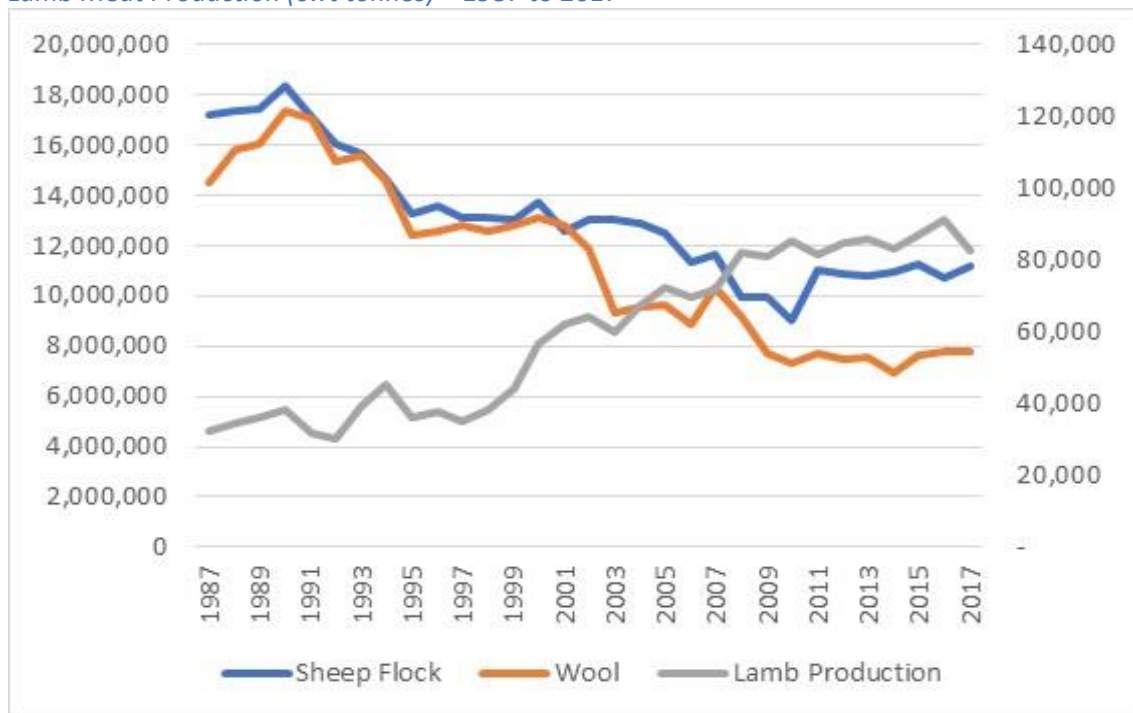


Sources: Australian Bureau of Statistics (ABS) (2013; 2017; 2018; 2018a; 2018b).

⁵ See Australian Bureau of Statistics (ABS) (2013).

⁶ See ABS (2017; 2018b).

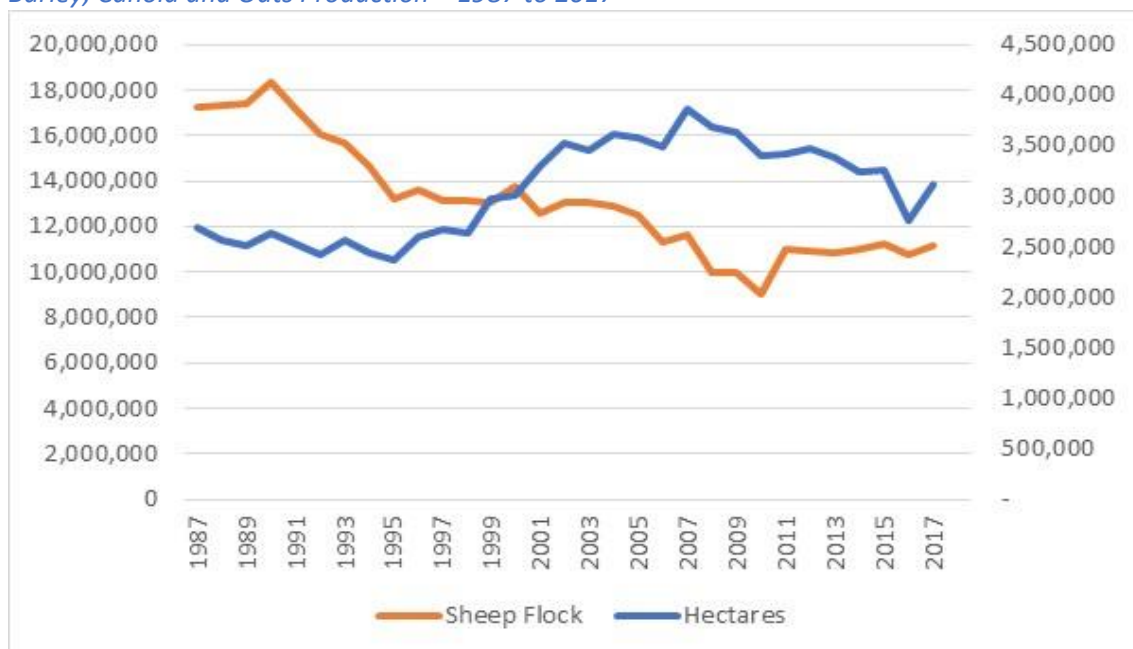
Figure 2: South Australian Sheep Flock Numbers, South Australian Wool Production (tonnes) and Lamb Meat Production (cwt tonnes) – 1987 to 2017



Sources: Australian Bureau of Statistics (ABS) (2013; 2017; 2018; 2018a; 2018b).

There is also an inverse relationship between the declining SA sheep flock and the trend increase in the number of hectares devoted to wheat, barley, canola and oats production in South Australia that is outlined in Figure 3 below. It is worth noting the amount of land devoted to wheat, barley and canola production can be influenced year-to-year by climatic conditions such as drought and commodity prices.

Figure 3: South Australian Sheep Flock Numbers and South Australian Hectares Devoted to Wheat, Barley, Canola and Oats Production – 1987 to 2017



Sources: ABS (2013; 2017; 2018b).

5 Live Sheep Exports

Sheep procured for the live export trade are usually either sold at saleyard auction or sold on-farm through paddock sales.

With saleyard auctions, sheep are transported to a central saleyard and sold to the highest bidder with prices reflecting supply and demand in the market on the day (Meat & Livestock Australia Limited, 2016a). Saleyards are the main pathway for farmers with smaller flocks who sell animals of varying standard and type in small lots, and for disposal of poorer stock (Australian Meat Industry Council, 2015, p. 17).

With paddock sales, livestock are inspected on the vendor's property by the buyer or their agent and sold from the paddock with buyers preferring to purchase in large numbers (Meat & Livestock Australia Limited, 2016a). Large buyers, such as meat processors and live exporters, prefer direct sales, rather than competing for stock via an auction (AuctionsPlus, 2015). Once procured, the sheep are usually transported to feedlots to await shipment to their final destination (Kingwell, et al., 2011, p. 22).

Rather than being a market for sheep in general, the live sheep export trade is primarily a trade in heavy wethers. Wethers are the most common type of Australian sheep exported live and are typically aged between one and two years (Deards, et al., 2014, p. 9). In 2012, 60.1 per cent of live sheep exports loaded from Fremantle, Port Adelaide and Portland were wethers, 22.9 per cent were male lambs, and 10 per cent were male hoggets and less mature rams (Norris & Norman, 2013, p. 8).

According to MLA (2001, p. 3), sheep for the live export trade should typically be as heavy and as fat as possible. A minimum of 50 kg liveweight seems to be preferred for wethers and 40 kg liveweight for hoggets.⁷

The main markets for Australian live sheep exports are countries in the Middle East. The live sheep export trade to the Middle East from Australia originally developed as an outlet for wool farmers seeking a market for their older wethers at the end of their wool-productive life (Kingwell, et al., 2011, pp. 4-5). However, MLA (2001, p. 3) has suggested that sheep need to have four permanent adult teeth or less for the Middle East live sheep export trade, in turn inferring that sheep need to be no more than two years old to be eligible for live export.⁸

While the production of prime lamb often needs to be a specialist enterprise, the production of wethers is usually combined with broadacre farming where sheep production is a sideline enterprise with cropping being their main management focus (Kingwell, et al., 2011, p. 40).

Australian live sheep exports grew substantially during the 1970s, as rising incomes and population growth resulted in increased meat demand in the Middle East (Deards, et al., 2014, p. 7). Sheep exports continued to grow in the 1980s, peaking at 7.3 million head in the 1983 calendar year (Deards, et al., 2014, p. 8).

However, Australia's live sheep export trade has been in trend decline since the 1980s. According to a report by the Australian Farm Institute (Keogh, Henry, & Day, 2016, p. 21):

The trade was interrupted by the turmoil associated with the cessation of the Wool Reserve Price Scheme in 1991 and associated initiatives such as the flock

⁷ Liveweight is the weight of the live animal (Meat & Livestock Australia Limited, 2016).

⁸ Sheep become six-tooth at between 27 and 29 months of age (Cashburn, 2016).

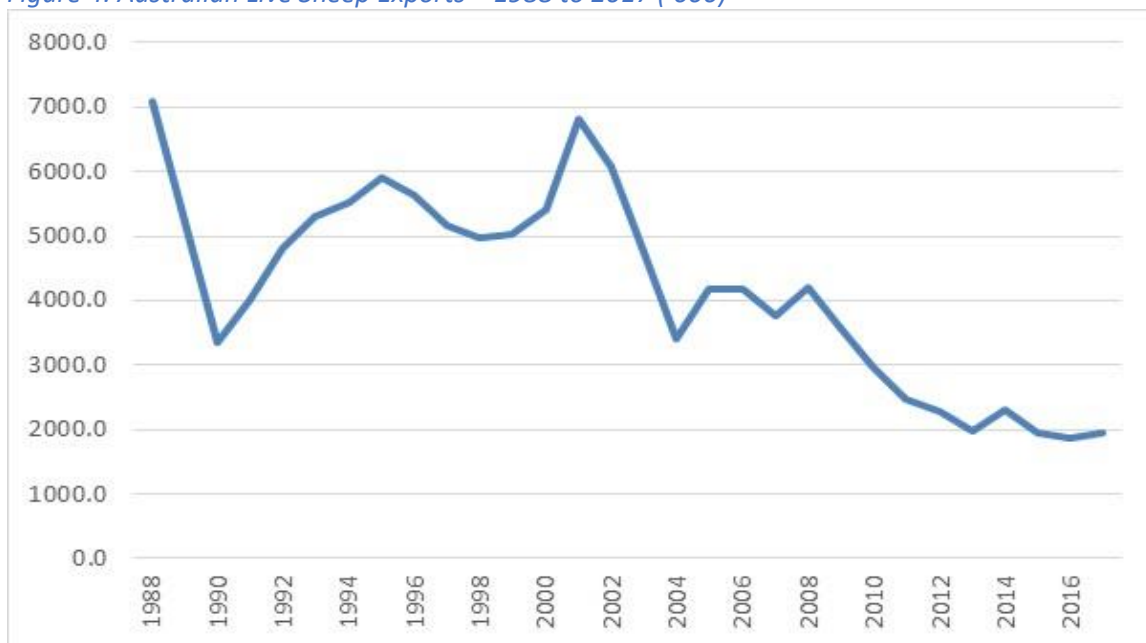
reduction scheme which resulted in the culling of 10 million sheep. It recovered somewhat during the mid-to-late 1990s, but the continuing decline in the size of the Australian sheep flock in combination with a switch by many woolgrowers to prime lamb production reduced the supply of merino wethers suitable for the live export trade, and annual sheep exports have been steadily declining since that time.

Similarly, according to a 2014 report by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (Deards, et al., 2014, p. viii):

Australia's live sheep exports have declined considerably since the 1980s, when annual exports frequently exceeded six million head each year.

Australian live sheep exports declined in the 1990s, following disruptions in trade to several markets and a fall in the number of sheep available for export (Deards, et al., 2014, p. 8). Although live sheep exports have more recently peaked at over 6 million per annum during 2001 and 2002, they have been in fairly continuous decline since then, falling to below 2 million per annum since 2014. This is outlined in Figure 4 below.

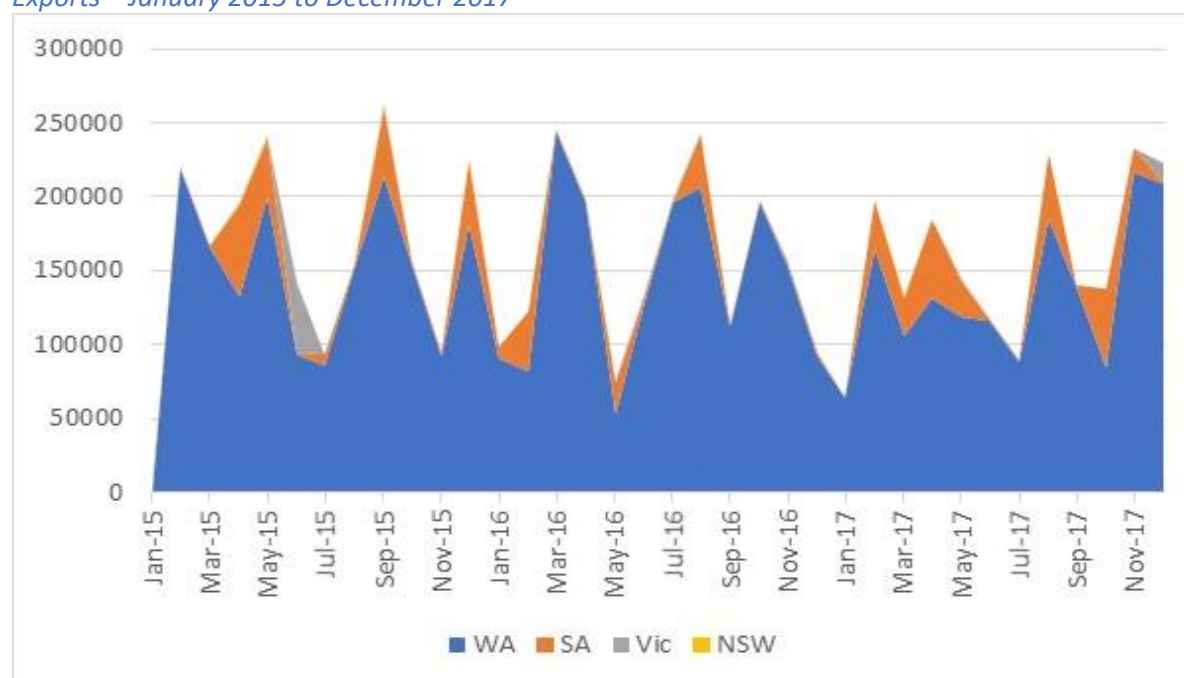
Figure 4: Australian Live Sheep Exports – 1988 to 2017 ('000)



Source: ABS (2018a).

The Australian live sheep export trade has been predominantly comprised of sheep sourced from Western Australia. Since the beginning of 2015, live sheep sourced from Western Australia have made up around 88 per cent of the Australian live sheep export trade by volume, with South Australia making up only 10 per cent by volume. This is outlined in Figure 5 below.

Figure 5: Western Australian, Victorian, South Australian and New South Wales Monthly Live Sheep Exports – January 2015 to December 2017



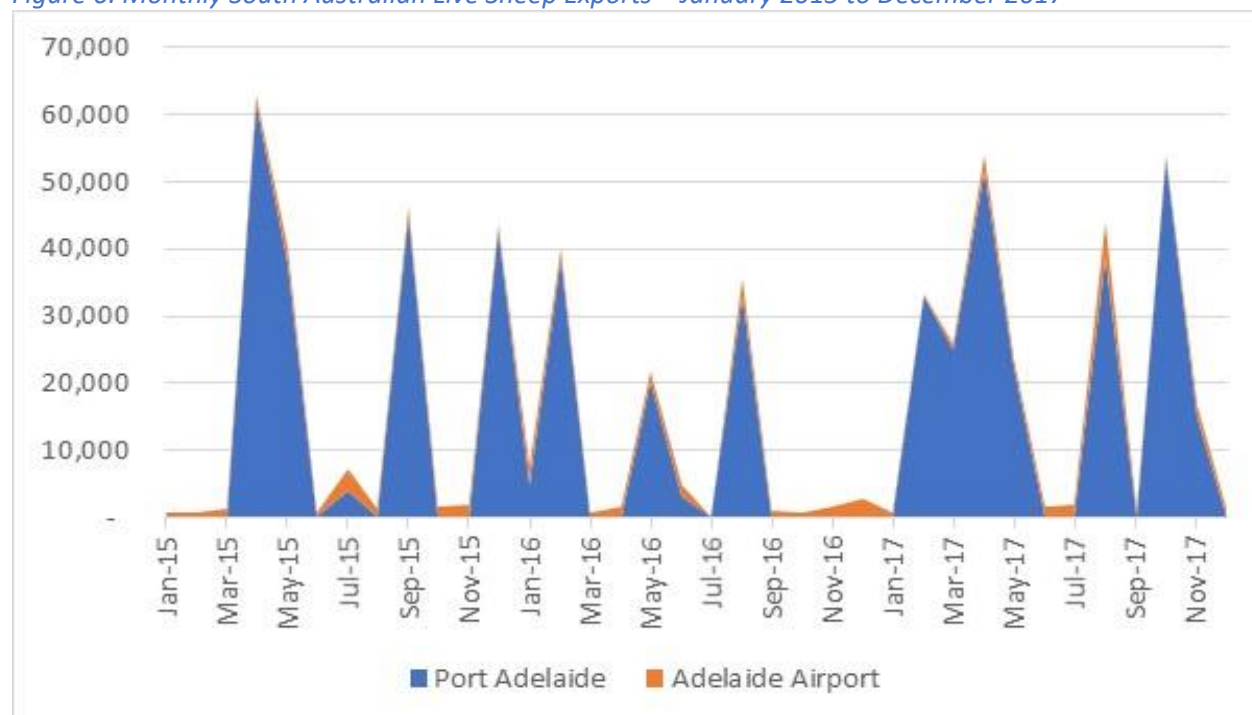
Source: MLA (2018).

Note: These figures also include sheep exported for breeding purposes although their numbers are fairly inconsequential.

When the supply of wethers in Western Australia is sufficient, voyages to the Middle East are usually loaded in Fremantle (Deards, et al., 2014, p. 53). It takes less time to reach the Middle East from Fremantle than Port Adelaide or Portland and the voyage is therefore less costly. Where consignments cannot be filled in Western Australia, or sheep can be purchased at sufficiently less cost elsewhere, exporters may purchase and load sheep from other states, now most commonly South Australia with the decline of Portland in Victoria as a loading port for the live sheep export trade.

Since the beginning of 2015, 91 per cent of live sheep exports from South Australia have been exported through ships loaded from the Common User Berth in the Inner Harbour at Port Adelaide. The remaining 9 per cent are transported via air freight from Adelaide Airport. Monthly South Australian live sheep exports from the beginning of 2015 are outlined in Figure 6 below.

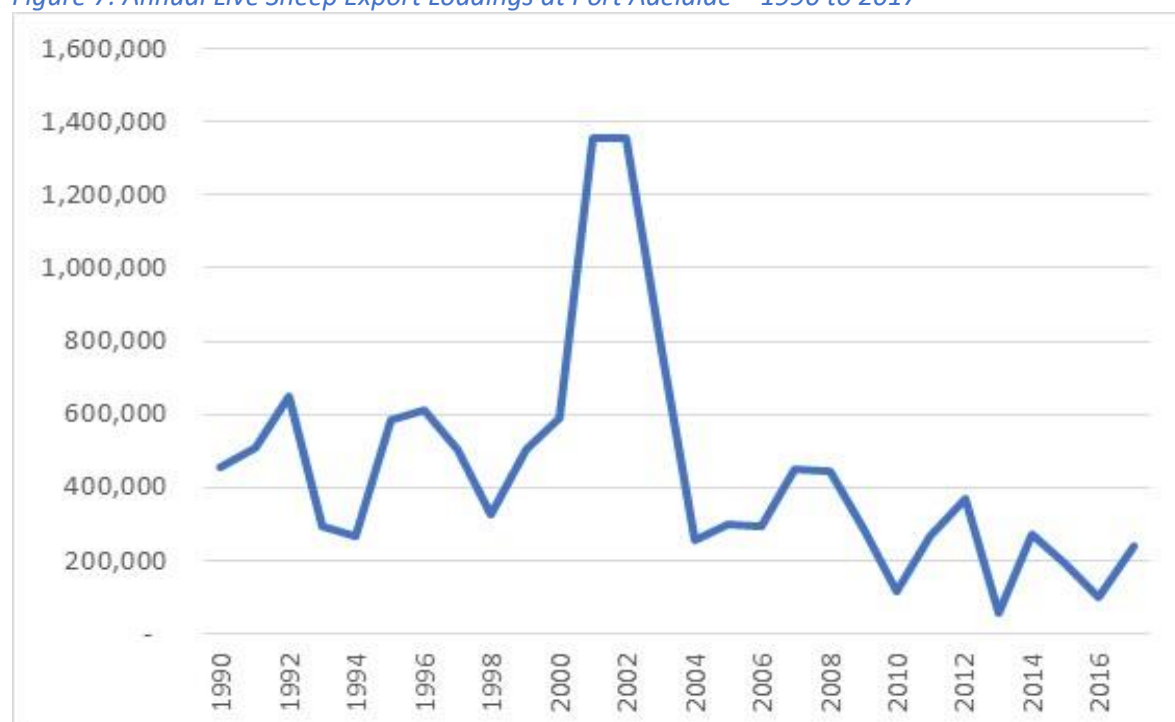
Figure 6: Monthly South Australian Live Sheep Exports – January 2015 to December 2017



Source: MLA (2018).

Similar to the Australian live sheep export trade, live sheep exports from South Australia have substantially declined since the early 2000's when annual loadings from Port Adelaide peaked in excess of 1.3 million during 2001 and 2002 and in 2017 it was less than 260,000. Annual loadings of live sheep for export from Port Adelaide is provided in Figure 7 below.

Figure 7: Annual Live Sheep Export Loadings at Port Adelaide – 1990 to 2017



Sources: Robinson (2007); LiveCorp & Meat & Livestock Australia Limited (2013, p. 8); Deards, et al., (2014, p. 74); Department of Agriculture and Food, Western Australia (2015, p. 8); Meat & Livestock Australia (2018).

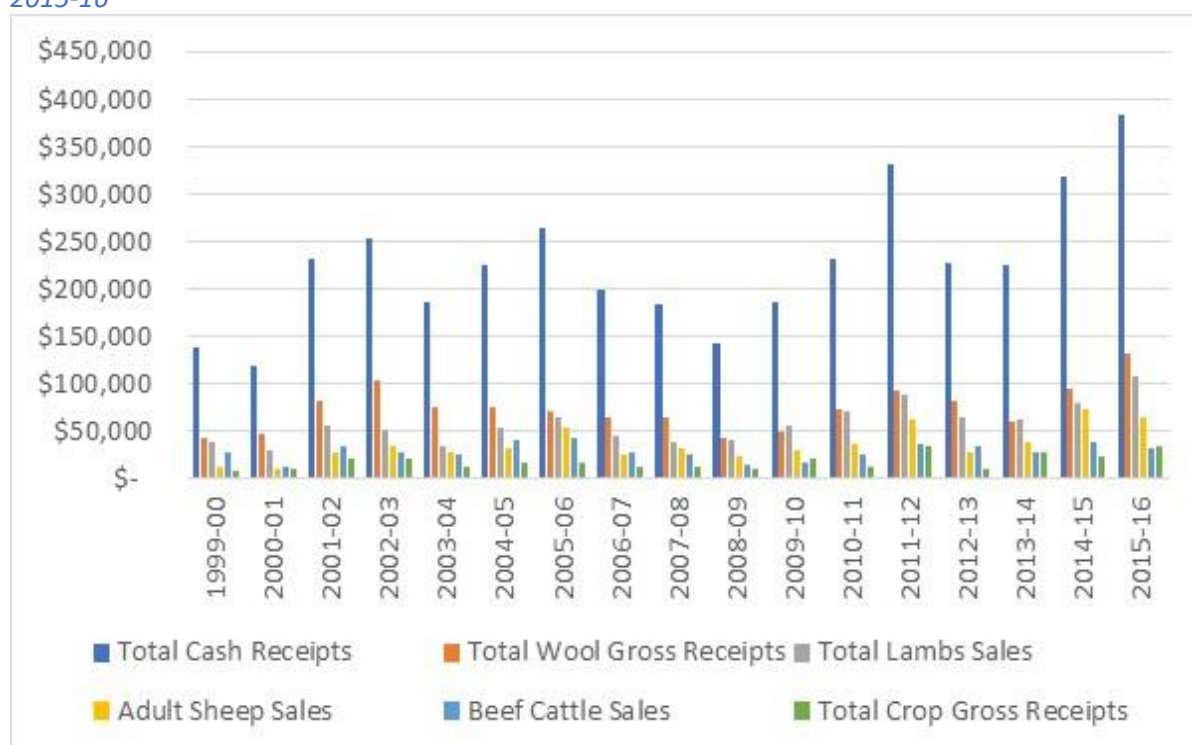
6 Significance of the Live Sheep Export Trade for South Australian Sheep Farmers

With the decline of the live sheep export trade, the relative significance of the trade for SA sheep farmers has also diminished. Even in the case of SA specialist sheep farmers the sale of sheep to the live export trade now only makes up only a relatively minor part of their enterprise.⁹

Although the relative significance of sheep sales for SA sheep farmers in terms of its contribution to total farm cash receipts has increased since 1999-2000 for both specialist sheep farmers and SA mixed enterprise sheep farms, the relative contribution of the live sheep export trade to sheep sales in terms of volume has significantly reduced.

While the percentage contribution of sheep sales to total farm cash receipts for SA specialist sheep farms has increased from 8.7 per cent in 1999-2000 to 17.1 per cent in 2015-16, the volume of sales going to the live sheep export trade has greatly reduced. This is outlined in Figures 8 and 9 below.

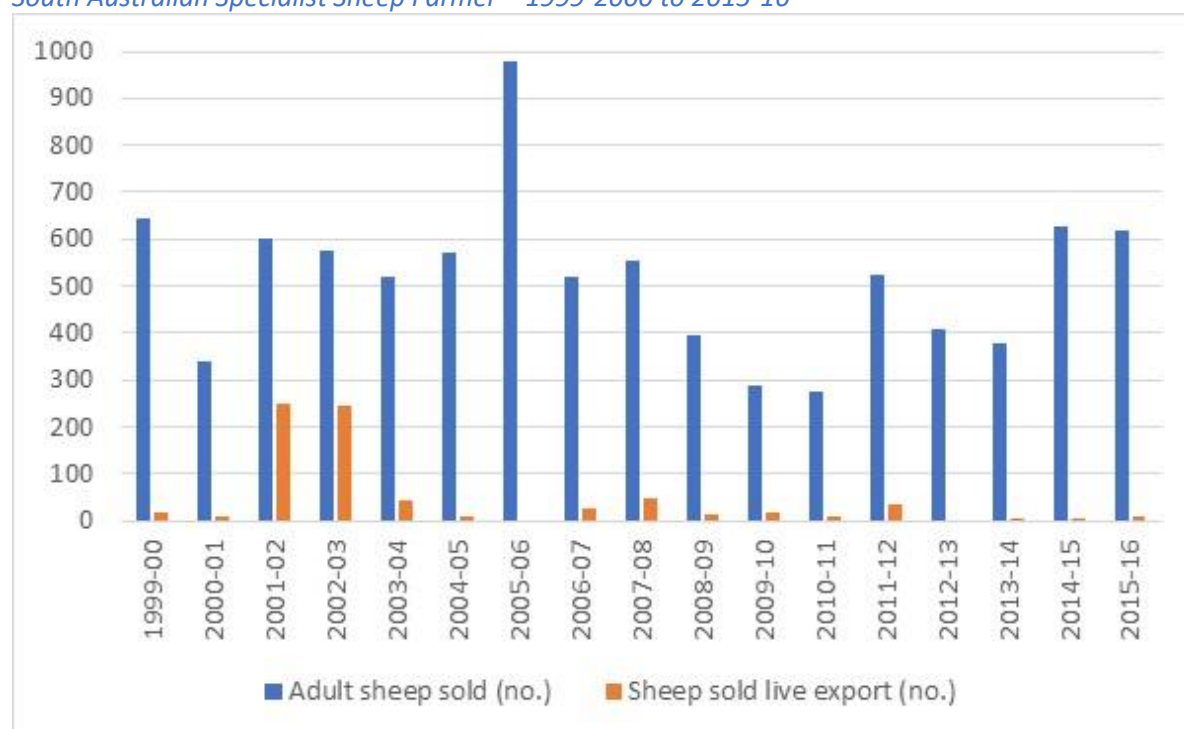
Figure 8: Average Farm Cash Receipts for a South Australian Specialist Sheep Farmer – 1999-2000 to 2015-16



Source: ABARES (2017c).

⁹ See ABARES (2017c). Specialist sheep farmer is defined as a farmer who receives more than 50 per cent of their receipts from the sale of sheep, lambs or wool.

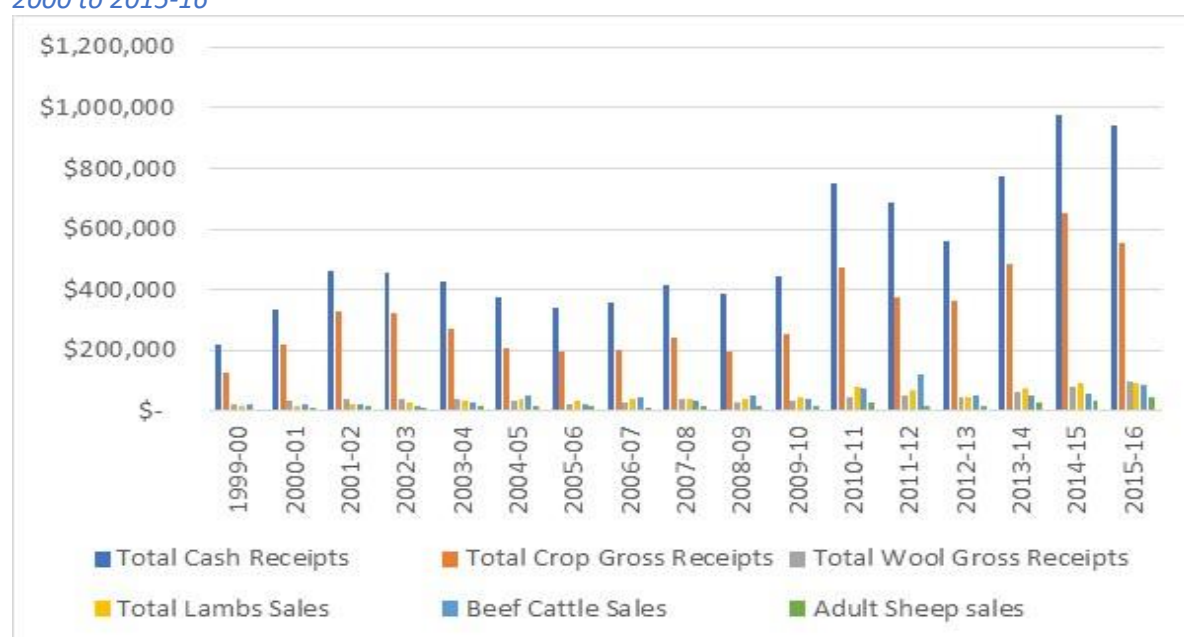
Figure 9: Average Adult Sheep Sales and Average Sales of Sheep to Live Sheep Exporters for a South Australian Specialist Sheep Farmer – 1999-2000 to 2015-16



Source: ABARES (2017c).

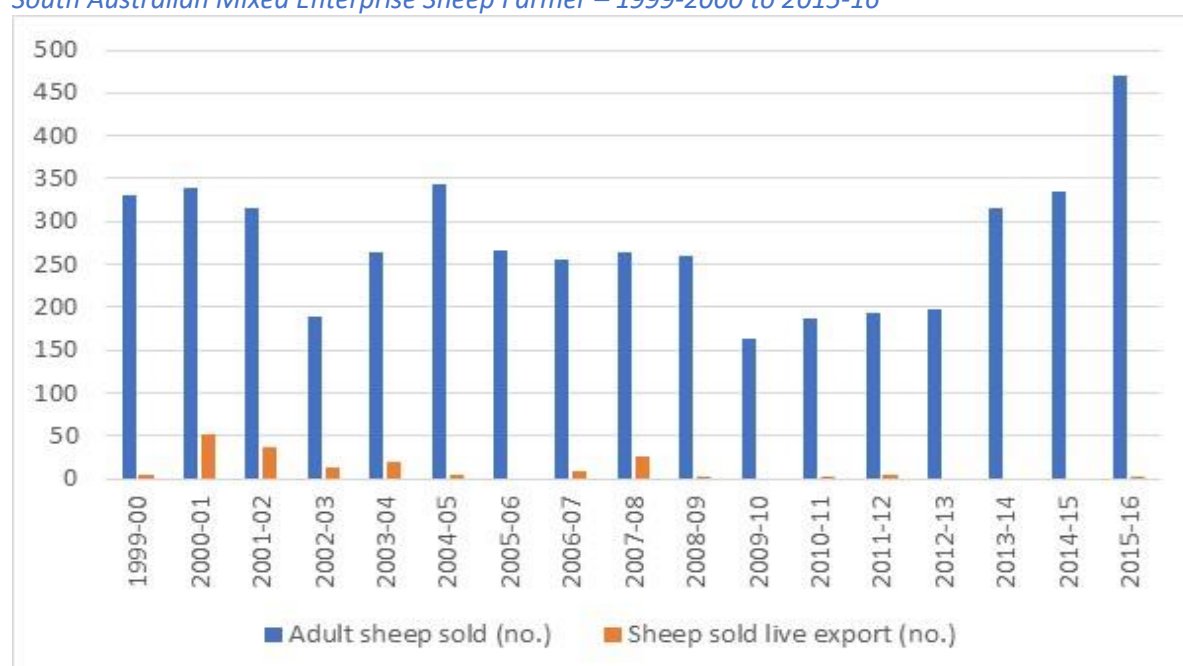
In the case of SA mixed enterprise sheep farms, while the percentage contribution of sheep sales to total farm cash receipts has increased from 2.9 per cent in 1999-2000 to 4.6 per cent in 2015-16, the volume of sales going to the live sheep has also greatly reduced. This is outlined in Figures 10 and 11 below.

Figure 10: Average Farm Cash Receipts for a South Australian Mixed Enterprise Sheep Farmer – 1999-2000 to 2015-16



Source: ABARES (2017c).

Figure 11: Average Adult Sheep Sales and Average Sales of Sheep to Live Sheep Exporters for a South Australian Mixed Enterprise Sheep Farmer – 1999-2000 to 2015-16



Source: ABARES (2017c).

7 Do Live Sheep Exporters Pay a Price Premium?

It has been found on several occasions that live sheep exporters pay a price premium over other purchasers of sheep at saleyard auctions in Western Australia.¹⁰ Most recently, a report by Pegasus Economics (2018) undertook a detailed analysis of auction price data from MLA saleyard reports from Western Australia between December 2014 to December 2017 comparing the prices paid by live exporters and those paid by other purchasers when both live exporters and other purchasers procured sheep on the same day at the saleyard auction. It was found that while there was a price premium being paid by live sheep exporters for wethers as compared to other purchasers, the price premium dissipates with the quality of the sheep; the heavier and better the condition of the sheep, the lower the price premium paid by live sheep exporters as compared to other purchasers.¹¹

The existence of a price premium for Western Australian sheep farmers selling to the live sheep export trade raises the question as to whether SA sheep farmers are beneficiaries of a similar price premium from the live sheep export trade. It was not possible to replicate the analysis conducted by Pegasus Economics based on MLA saleyard reports from Western Australia as MLA does not publish data on the live sheep export purchasers at saleyard auctions in South Australia. This may reflect the fact that live sheep exporters procure sheep primarily through paddock sales in South Australia rather than through saleyard auctions. Consultations with parties involved in the procurement of sheep in South Australia have confirmed that live sheep exporters usually procure sheep through paddock sales rather than through auction. In this situation, an analysis of the live sheep export

¹⁰ See Lindner, et al., (2004, p. 16); Clarke, Morison, & Yates (2007, p. 89); Davey (2013); and Davey and Fisher (2018).

¹¹ The condition of the sheep can be measured by the fat score. Fat score is the fat measurement on the carcass, based on the actual soft tissue depth at the Girth Rib (GR) site that is over the 12th rib of the sheep (Meat & Livestock Australia, 2017, p. 2). For sheep the fat scores are generally interchangeable with condition scores (Gaden, Duddy, & Irwin, 2005, p. 2).

trade upon South Australian sheep prices must resort to indirect measures to determine any price impact.

For this exercise the South Australian mutton indicator has been compared to the mutton indicator in New South Wales and Victoria to determine whether or not there are any relative changes in South Australian mutton prices prior to the departure of a live sheep export shipment from Port Adelaide in excess of 10,000 head of sheep as compared to Victoria and New South Wales. It was found there was a much stronger correlation between the Victorian and South Australian mutton indicator than there was between the New South Wales and South Australian mutton indicator. However, there was a close correlation between all three mutton indicators as outlined in Figure 12 below.

Figure 12: New South Wales, Victorian and South Australian Mutton Saleyard Indicator for Mutton (cents per kilogram (c/kg) carcase weight (cwt)) – 16 December 2014 to 14 December 2017



Source: MLA.

It was not possible to obtain data on the exact date of departure of live sheep export shipments from Port Adelaide so a number of alternative proxies were used as a substitute to reflect the period in which sheep would be procured for shipment.

The proxy that provided the best fit for the data was for the month prior to the departure of a live sheep export shipment from Port Adelaide. All proxies used were statistically significant and were negative, in turn inferring in the period leading up to the departure of a live sheep export shipment from Port Adelaide there was a negative price impact on the South Australian mutton indicator. In turn these results strongly suggest there is no price premium being paid by live sheep exporters to South Australian sheep farmers, unlike sheep farmers in Western Australia. This is consistent with the observations of Victorian prime lamb farmer Patrick Francis (2014):

In reality the questions surrounding phasing out live sheep exports centers directly around impacts on WA sheep farmers. Eastern states sheep farmers rely very little on the live trade and if it no longer existed would have virtually no impact on business profitability.

Consultations with parties involved in sheep purchasing in South Australia suggest that live sheep exporters focus primarily on procuring sheep that are lighter and of lower quality, and do not compete against sheep meat processors to procure heavier and higher quality sheep. The views of these parties were that live sheep exporters had little price impact on SA sheep prices.

Further details of the modelling are provided in Appendix 1.

8 Capacity of South Australian Sheep Meat Processors

In the normal course of events, sheep processing capacity for SA abattoirs is estimated conservatively at around 6 million sheep per annum based on a potential weekly throughput of 117,000. This is outlined in Table 1 below. For those abattoirs that have only quoted a daily processing capacity, this assumes a 5 day working week that could potentially be extended into the weekend.

Table 1: Estimated Processing Capacity of SA abattoirs to Slaughter Sheep per week

Abattoir	Capacity per week
Thomas Foods International (Murray Bridge)	52,000
JBS Australia Pty Ltd (Bordertown)	40,000
Thomas Foods International (Lobethal)	24,000
Total	117,000

Sources: Thomas Foods International (2018); JBS Australia Pty Ltd (JBS Australia Pty Ltd, 2018).

Based on the number of lamb and sheep slaughtered in South Australia during 2017, SA sheep meat processors appear to be running at around 76 per cent of capacity. This leaves spare processing capacity in excess of 1.4 million sheep per annum.

It should be noted the Thomas Foods International abattoir at Murray Bridge was badly damaged by a fire in early January 2018 sparked by a maintenance worker who was welding a bin (McCarthy, 2018). However, Thomas Foods International (2018a) have committed to rebuilding the Murray Bridge abattoir.

All of the abattoirs listed in Table 1 are export licenced. In addition, there are two other abattoirs in South Australia accredited for the processing of sheep meat for domestic purposes, namely:

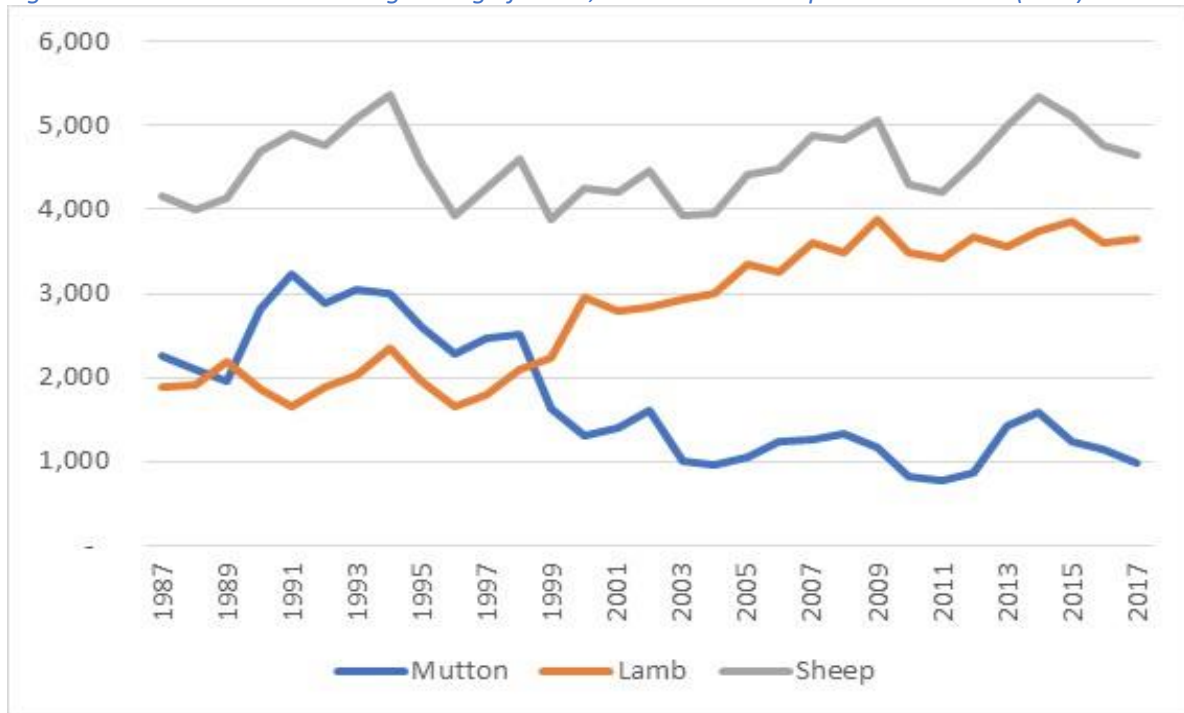
- Meatpak Australia Pty Ltd (trading as HOLCO) (Caavan); and
- Austral Meat (Gepps Cross) (AUS-MEAT Limited, 2018).

At its most recent peak, SA abattoirs slaughtered just over 5.3 million sheep (lamb and mutton combined) in 2014, which has since fallen back to around 4.6 million during 2017.¹² Over the course of the past 20 years growth in slaughtering has been largely driven by an increase in lamb that has been partially offset by a steady decline in mutton.¹³ This is outlined in Figure 13 below.

¹² See ABS (2018).

¹³ Ibid.

Figure 13: South Australian Slaughtering of Lamb, Mutton and Sheep – 1987 to 2017 (000')



Source: ABS (2018).

On current utilisation levels, the SA meat processing industry has sufficient spare capacity to absorb the entire quantum of live sheep exported annually from South Australia and still have spare capacity to process almost another 1.2 million sheep per annum.

9 Economic Impact from Phasing Out of the Live Sheep Export on South Australia

In the absence of any evidence suggesting there is a price premium being paid by live sheep exporters to South Australian sheep farmers to procure stock, there would appear to be very little downside for the South Australian economy from the cessation of the trade. In fact, the cessation of the live sheep export trade would provide a small fillip to the South Australian economy through further value adding by meat processors.

In the event that sheep sales to the live sheep export trade was no longer an option for SA sheep farmers, sheep diverted away from live export could be redirected towards several alternative options, including the following:

1. keep the wethers until cast (at the end of productive life) primarily to cut wool;
2. finish sheep earlier to meet lamb market specifications;
3. sell the wethers as store sheep to be fattened before sale for slaughter; or
4. keep the wethers until they reach the heavier weights required for the slaughter market.

Where wethers are retained in the sheep production system for cutting wool, they are typically kept until 5 or 6 years of age and then sold (when they are called 'cast for age') (Barber, 2009, p. 24). At this age these sheep have reached the end of their productive life and are sold into the meat processing market. Option 1 depends upon wool market prices that are currently at record highs in nominal terms and forecast to go even higher. In 2017-18 the Australian Eastern Market Indicator

(EMI) wool price is forecast to rise by 15 per cent to an average 1,630 cents per kilogram driven by higher prices for fine and superfine wools (Australian Bureau of Agricultural and Resource Economics and Sciences, 2017, p. 62).

The decision to sell into higher value lamb markets under option 2 means the sheep would need to be of a weight suitable for slaughter before the first adult teeth appear at around 14 months of age (Barber, 2009, p. 24).

The price received by sheep farmers under options 3 and 4 will ultimately depend on the demand by processors for sheep to produce mutton. As Australians consume very little mutton (Wong, Selvanathan, & Selvanathan, 2015, p. 1; Australian Bureau of Agricultural and Resource Economics and Sciences, 2017a, p. 110), processor demand for sheep to produce mutton will be driven by export markets for mutton.

In the absence of any evidence of a price premium being paid to SA sheep farmers by live sheep exporters, it would appear the cessation of the live sheep export trade will have little material impact on SA sheep farmers. On the other hand, the cessation of the live sheep export trade will have a positive material impact on SA sheep meat processors.

While some have claimed the live export trade is complementary to domestic meat processing (Keogh, Henry, & Day, 2016), this view has been contested by some in the meat processing sector. According to Tom Macguire, General Manager of Corporate Services at red meat processor Teys Australia:

There is no doubt that the live export industry cannibalises the value-add which meat processing otherwise generates for the Australian economy. (Cranston, 2011)

Essentially, domestically processed sheep meat product exports to the Middle East are in direct competition against Australian live sheep exports that are processed in the Middle East. Thus, live sheep exports also result in the export of meat processing and the associated employment and income generated overseas.

According to Victorian prime lamb farmer Patrick Francis (2014), the live sheep export trade faces questions surrounding its economics given the product is a generic, non-value-added commodity. In stark contrast, the phasing out of the live sheep export trade will provide SA sheep meat processors with the opportunity to engage in further value adding activities.

Meat processors 'add value' by transforming livestock into meat and other co-products (Industry Commission, 1994, p. 240). Value added is calculated as the revenue from sales less the cost of purchased materials (including livestock) and services (Industry Commission, 1994, pp. 35-36). Value added is the value of an abattoir's output which is available to reward the factors of production employed – the employees, management and capital (Industry Commission, 1994, p. 35). It is thus the sum available from which profits and wages must be derived (Industry Commission, 1994, p. 240). According to the former Industry Commission (1994, p. 36), labour accounts for 97 per cent of the value added for meat processors.

The cessation of the live sheep export trade will provide for the redirection of some sheep to domestic processors that in turn will enable them to raise their capacity utilisation and employment levels. It would also improve economies of scale in meat processing, making processed sheep meat

products more price competitive.¹⁴ An increase in employment due to the engagement of unemployed and/or underemployed people will generate higher economic growth and a reduction in unemployment benefits coupled with a reduced financial impost on taxpayers.

10 Significance of Live Sheep Exports to the Overall Sheep Meat Trade

Ongoing instances of animal cruelty that have plagued the live export trade pose a reputational risk to the rest of Australian agriculture that risks being tarred with the same brush.¹⁵ While the Australian Government has attempted to improve animal welfare standards through the adoption of the Australian standards for the export of livestock (ASEL) and the Exporter Supply Chain Assurance Scheme (ESCAS) and thus ameliorate the reputational risk to Australian agriculture, it cannot eliminate it entirely. As Benjamin Franklin once said:

It takes many good deeds to build a good reputation, and only one bad one to lose it. (Eccles, Newquist, & Schatz, 2007, p. 106)

Arguably, the parts of Australian agriculture most at risk from another animal cruelty incident associated with the live sheep export trade are sheep producers not engaged in the live export trade. This is consistent with the findings of 2003 Livestock Export Review chaired by Dr John Keniry that was commissioned by the Australian Government:

The Review concluded that there must be recognition that the livestock export industry cannot afford more bad outcomes and therefore all higher risk voyages should be eliminated. In those circumstances where there is clear evidence of a risk that demonstrably contributes to adverse outcomes on a predictable basis, exports should not be permitted. (Keniry, Bond, Caple, Gosse, & Rogers, 2003, p. 42)

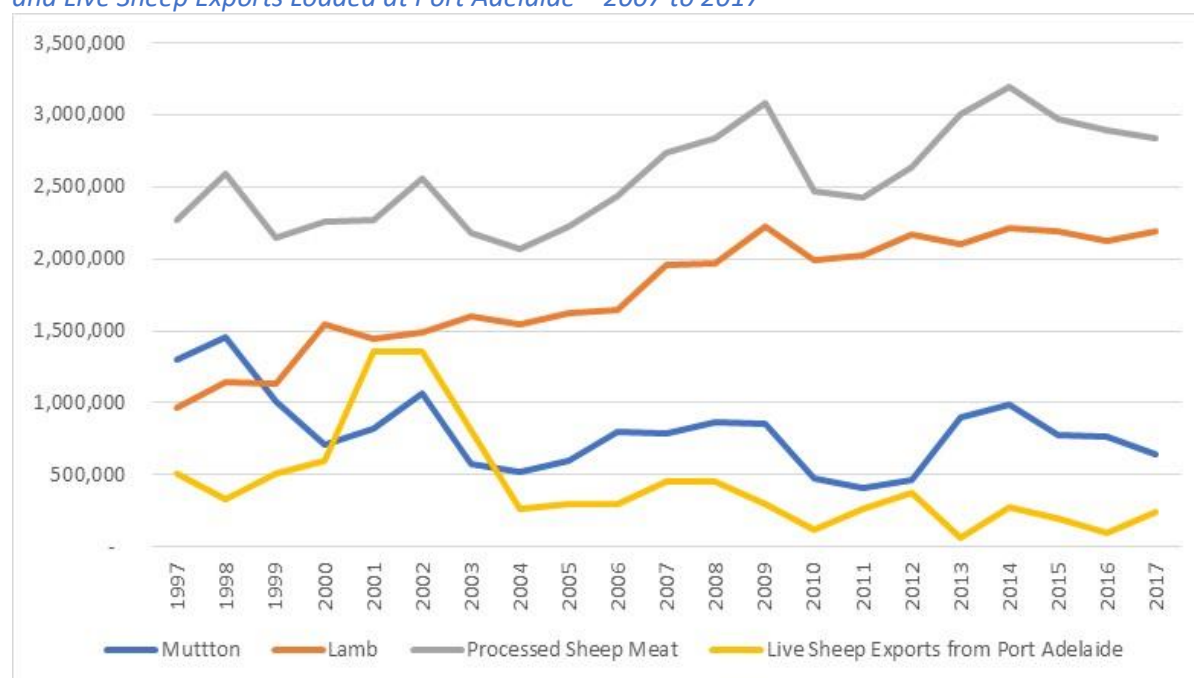
Live sheep exports loaded from Port Adelaide have been the least significant component of South Australia's sheep meat exports in volume terms since 2004 when carcase equivalent mutton exports surpassed live sheep exports.¹⁶ In 2017, South Australia exported over 10 times the volume of carcase equivalent processed sheep meat than live sheep exports loaded from Port Adelaide. This is outlined in Figure 14 below.

¹⁴ Economies of scale occur when average costs decline as output decreases.

¹⁵ Reputational risk has been defined as a negative event that will impact stakeholders' perception of a company (Gillen, 2009).

¹⁶ The one exception to this is live sheep exports air freighted from Adelaide Airport although this is a fairly recent phenomenon and relatively small component of the overall live sheep export trade and will not be considered further for the purposes of this comparison.

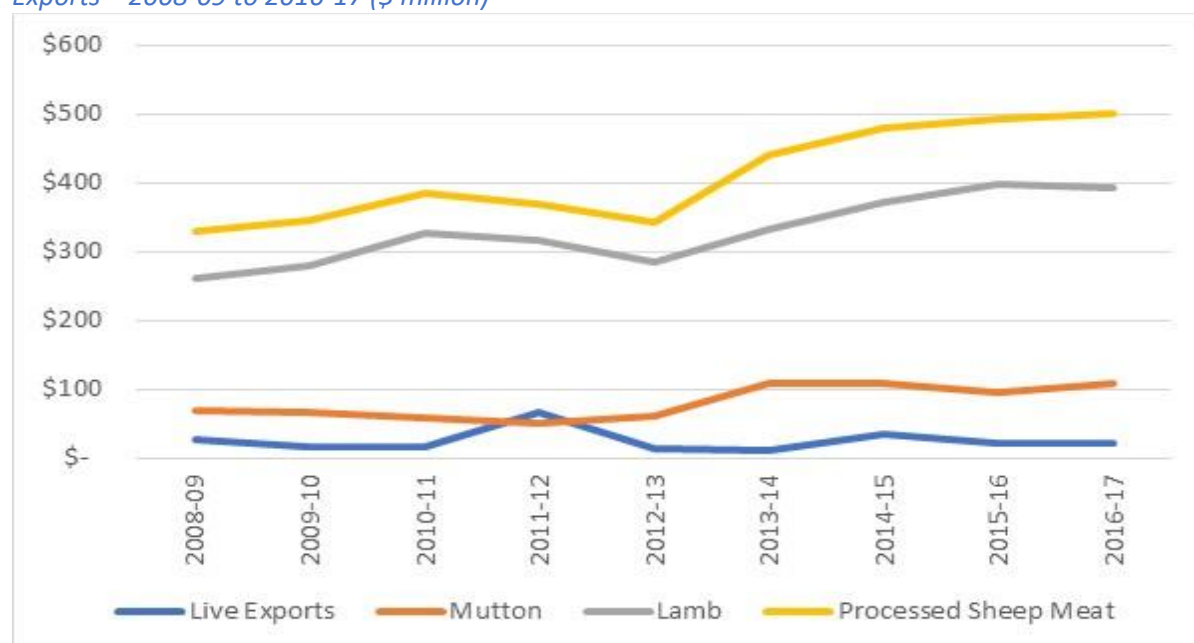
Figure 14: Carcase Equivalent Exports of South Australian Mutton, Lamb and Processed Sheep Meat and Live Sheep Exports Loaded at Port Adelaide – 2007 to 2017



Sources: Department of Agriculture, Fisheries and Forestry red meat export statistics from 2007 to 2017 and the MLA Market Information Statistics Database for calendar year average carcase weights for mutton and lamb.

The value of processed sheep meat exports from South Australia of around \$500 million in 2016-17 was in excess of 20 times the value of live sheep exports from South Australia of around \$23 million in 2016-17. This is outlined in Figure 15 below.

Figure 15: Estimated Value of South Australian Mutton, Lamb, Processed Sheep Meat and Live Sheep Exports – 2008-09 to 2016-17 (\$ million)*



Sources: ABARES (2017b), MLA (2015; 2018).

* Estimated exports values for South Australian based on South Australian export volumes as a percentage of national export volumes and applying those percentages to national export values, except for South Australian live sheep exports from 2008-09 to 2014-15 that are based on actual published values.

11 Conclusions

The significance of the live sheep export trade for SA sheep farmers has substantially diminished since the early 2000s. Furthermore, there is no evidence to suggest that SA sheep farmers would be worse off in the event of the cessation of the live sheep export trade.

On the other hand, the cessation of the live sheep export trade will provide a positive material benefit to the SA sheep meat processor sector enabling it to engage in further value added processing rather than seeing the value added processing exported overseas through the live sheep export trade.

Appendix 1: Estimating Price Impact of the Live Sheep Export Trade on South Australian Sheep Prices

As already discussed in section 7 above, MLA does not publish data on the live sheep purchasers at saleyard auctions in South Australia. This may reflect the fact that live sheep exporters procure sheep primarily through paddock sales in South Australia rather than through saleyard auctions. In this situation, any analysis of the live sheep export trade upon South Australian sheep prices must resort to indirect measures to determine any price impact.

In this case, the daily South Australian mutton indicator based on saleyard auction prices has been used to determine whether the impending departure of a live export ship from Port Adelaide has any material impact on the relative scarcity of sheep in South Australia as compared to the mutton indicator in Victoria and New South Wales.

The following equation has been estimated for the SA mutton indicator (SAM) as a function of a constant term (β_0), the New South Wales mutton indicator ($NSWM$), the Victorian mutton indicator ($VICM$), a dummy variable representing the time period prior to the departure of a significant live sheep export shipment from Port Adelaide (LE) and an error term (ε) and a subscript (t) representing the time period:¹⁷

$$SAM_t = \beta_0 + \beta_1 NSWM_t + \beta_2 VICM_t + LE_t + \varepsilon_t \quad (1)$$

The following variations of equation (1) were also run:

$$SAM_t = \beta_0 + \beta_1 VICM_t + LE_t + \varepsilon_t \quad (2)$$

$$SAM_t = \beta_0 + \beta_1 NSWM_t + LE_t + \varepsilon_t \quad (3)$$

A series is stationary if its mean and variance is time invariant. However, any series that is not stationary is said to be nonstationary or to contain a unit root. If a first difference is taken of a nonstationary time series and found to be stationary then the series is said to be integrated of the first order or $I(1)$, or to contain one unit root.

The price series SAM , $NSWM$ and VM along with their first differences were tested for stationarity using the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The KPSS test performs the test that a series is stationary as the null hypothesis against the alternative hypothesis for the presence of a unit root. Results from the KPSS test are provided in Table 2 below.

¹⁷ Significant live sheep export shipments from Port Adelaide were taken to be shipments in excess of 10,000 head of sheep.

Table 2: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test with two specifications

Variable	KPSS with a constant	KPSS test with a constant and linear time trend
<i>SAM</i>	1.194 [#] (0.463)	0.242 [#] (0.146)
Δ <i>SAM</i>	0.060* (0.463)	0.052* (0.146)
<i>NSWM</i>	1.716 [#] (0.463)	0.320 [#] (0.146)
Δ <i>NSWM</i>	0.139* (0.463)	0.047* (0.146)
<i>VICM</i>	1.820 [#] (0.463)	0.286 [#] (0.146)
Δ <i>VICM</i>	0.043* (0.463)	0.041* (0.146)

Note: Figures in brackets are the corresponding critical values at the 5 per cent level of statistical significance. # indicates that the null hypothesis of a stationary series has been rejected at the 5 per cent level. * indicates that the null hypothesis of a stationary series has been accepted at the 5 per cent level.

As one would expect in relation to commodity price time series data, the three price series tested proved to be nonstationary and integrated of the first order.

Estimates of relationships between nonstationary variables could lead to spurious regression by suggesting significant relationships between wholly unrelated variables (Granger & Newbold, 1974).

A standard approach to addressing the problem of nonstationary data has been to specify models as relationships between differences. However, the major drawback from this approach is that a model based solely on difference terms can only capture the short-run dynamics in a process and therefore fails to identify any long-run relationships between the variables.

Given the price series under consideration are integrated of the same order, it is likely that a linear combination of these variables will be stationary. Granger (1981) coined the term cointegration to describe a stationary combination of nonstationary variables.

Dynamic ordinary least squares (DOLS) was used to estimate the model described above. DOLS enables a cointegrating relationship to be modelled as a single equation, rather than the two equation error-correction model (ECM) approach where the residuals from the long-run equilibrium regression are entered into the ECM in the place of the levels terms as proposed by Engle and Granger (1987).

The model was estimated using the heteroskedasticity and autocorrelation-consistent (HAC) standard errors as developed by Newey and West (1987). This will ensure the standard errors are robust in the event of both heteroskedasticity and autocorrelation of an unknown form.

The model estimated was tested for cointegration using various diagnostic tests and found to be cointegrated.¹⁸ Eviews 8.1 was used for the modelling.

Under the intervention analysis proposed by Box and Tiao (1975), an indicator (or dummy) variable is included in the model which takes only the values of 0 and 1 to denote the non-occurrence and occurrence of the intervention as long as the timing of the intervention is known. To test for the

¹⁸ The Engle-Granger and Phillips-Ouliaris residual-based tests for cointegration were used.

potential price impact of the live sheep export trade on SA sheep prices, the dummy variable *LE* has been included in the model. Because the exact date departure of live sheep export shipments from Port Adelaide were not known, several different configurations for *LE* were used in the analysis, including:

- the month prior to the departure of the live sheep export shipment from Port Adelaide;
- the last three weeks of the month prior to the departure and the first week of the month of the departure of the live sheep export shipment from Port Adelaide;
- last two weeks of the month prior to the departure and the first fortnight of the month of departure of the live sheep export shipment from Port Adelaide; and
- five weeks prior to the month of departure of the live sheep export shipment from Port Adelaide.¹⁹

It was assumed there would be a period of several weeks required prior to the departure of a live sheep export shipment for the procurement of sheep and organise the logistics for an export shipment. All configurations of *LE* used were statistically significant at least at the 5 per cent level. The configuration of *LE* that provided the best fit of the data was for the month prior to the departure of the live sheep export shipment from Port Adelaide. Only the results for equations (1), (2) and (3) with the configuration of *LE* that provided the best fit of the data is report in Table 3 below.

Table 3: DOLS regression for equations (1), (2) and (3) (HAC t-statistic probabilities in brackets)

Variable	Equation (1)	Equation (2)	Equation (3)
<i>Constant (β_0)</i>	59.449 (0.001)	49.846 (0.002)	40.653 (0.052)
<i>NSWM</i>	-0.192 (0.110)		0.810 (0.000)
<i>VICM</i>	0.941 (0.000)	0.776 (0.000)	
<i>LE</i>	-30.983 (0.000)	-20.726 (0.000)	-19.710 (0.001)
<i>R-squared</i>	0.725	0.720	0.638
<i>Adjusted R-squared</i>	0.721	0.718	0.635

¹⁹ The variation to this was around December 2016 and January 2017 when there was a reduced number of observations available, so all configurations for *LE* was taken back to mid-December 2016 to account for a live sheep export shipment departing Port Adelaide in February 2017.

Bibliography

- AuctionsPlus. (2015). *Submission to the Senate Standing Committee on Rural and Regional Affairs and Transport Inquiry on the Effect of market consolidation on the red meat processing sector*. Sydney.
- AUS-MEAT Limited. (2018). *AUS-MEAT Accredited Search*. Retrieved from AUS-MEAT Limited: <https://www.ausmeat.com.au/links-tools/accreditation-search/>
- Australian Bureau of Agricultural and Resource Economics and Sciences. (2017). *Agricultural Commodities: December Quarter 2017*. Canberra: Department of Agriculture and Water Resources.
- Australian Bureau of Agricultural and Resource Economics and Sciences. (2017a). *Agricultural Commodities: March quarter 2017*. Canberra: Department of Agriculture and Water Resources.
- Australian Bureau of Agricultural and Resource Economics and Sciences. (2017b). *Australian Commodity Statistics 2017*. Canberra: Department of Agriculture and Water Resources.
- Australian Bureau of Agricultural and Resource Economics and Sciences. (2017c, April). Farm survey data for the beef, slaughter lambs and sheep industries. Canberra.
- Australian Bureau of Agricultural and Resources Economics. (2004). *Australian lamb 04.1: prime lamb industry - performance and outlook to 2003-04*. Canberra.
- Australian Bureau of Statistics. (2013). *Historical Selected Agricultural Commodities, by State (1861 to Present), 2010-11, ABS Cat. no. 7124.0*. Canberra.
- Australian Bureau of Statistics. (2017). *Agricultural Commodities, Australia, 2015-16, ABS Cat. no. 7121.0*. Canberra.
- Australian Bureau of Statistics. (2018). *Livestock and Meat, Australia, December 2017 - ABS Cat. no. 7218.0.55.001*. Canberra.
- Australian Bureau of Statistics. (2018a). *Livestock Products, Australia, Dec 2017, ABS Cat. no. 7215.0*. Canberra.
- Australian Bureau of Statistics. (2018b). *Principal Agricultural Commodities, Australia, Preliminary, 2016-17, ABS Cat. no. 7111.0*. Canberra.
- Australian Meat Industry Council. (2015). *Submission to the Senate Standing Committee on Rural and Regional Affairs and Transport Inquiry into the effect of market consolidation on the red meat sector*. Sydney.
- Australian Surveying and Land Information Group. (1990). *Tactical Atlas of Australia: Volume 2 - People and Industry, Maps*. Canberra: Department of Administrative Services.
- Barber, M. (2009). *The Value of Live Sheep Exports From Western Australia: A Review of Adjustments That Would Be Required If Live Sheep Exports From WA Ceased*. Canberra: ACIL Tasman Report prepared for the RSPCA Australia.
- Bardsley, P. (1994). The Collapse of the Australian Wool Reserve Price Scheme. *The Economic Journal*, 104, 1087-1105.

- Biosecurity Tasmania. (2014). *Sheep: Guide for Hobby Farmers and Smallholders - Some basic health and welfare tips from DPIPW*. Hobart: Department of Primary Industries, Parks, Water and Environment.
- Box, G. E., & Tiao, G. C. (1975). Intervention Analysis with Applications to Economic and Environmental Problems. *Journal of the American Statistical Association*, 70(349), 70-79.
- Bruce, A. (2012). *Animal Law in Australia: An Integrated Approach*. Sydney: LexisNexis Butterworths.
- Cashburn, G. (2016). *How to tell the age of sheep*. Wagga Wagga: Government of New South Wales Department of Primary Industries.
- Cashin, P., & McDermott, C. J. (2002). 'Riding on the Sheep's Back': Examining Australia's Dependence on Wool Exports. *Economic Record*, 78(242), 249–263.
- Chow, K. (2013). Sheepmeat: Outlook to 2017–18. *Agricultural commodities: Research by the Australian Bureau of Agricultural and Resource Economics and Sciences*(March quarter 2013), 96-103.
- Clarke, M., Morison, J., & Yates, W. (2007). *The Live Export Industry: Assessing the Value of the Livestock Export Industry to Regional Australia*. Sydney: Meat & Livestock Australia Limited.
- Cranston, M. (2011, June 2). Abattoirs fight live cattle trade. *The Australian Financial Review*, p. 14.
- Dahl, A., Leith, R., & Gray, E. (2013). Productivity growth in the broadacre and dairy industries. *Agricultural commodities: Research by the Australian Bureau of Agricultural and Resource Economics and Sciences*(March Quarter), 200-220.
- Davey, A. (2013). *Economic impact of phasing out the live sheep export trade: Report prepared for the World Society for the Protection of Animals - March 2013*. Canberra: Sapere Research Group.
- Davey, A., & Fisher, R. (2018). *Economic Issues Associated with the Live Sheep Export Trade*. Canberra: Pegasus Economics.
- Deards, B., Leith, R., Mifsud, C., Murray, C., Martin, P., & Gleeson, T. (2014). *Live export trade assessment*. Canberra: ABARES report to client prepared for the Live Animal Exports Reform taskforce of the Department of Agriculture.
- Department of Agriculture. (2014). *Mortality Investigation Report 46: Sheep exported to Qatar and the United Arab Emirates in September 2013*. Canberra.
- Department of Agriculture and Food, Western Australia. (2015). *National livestock export industry sheep, cattle and goat transport performance report 2014*. Sydney: Meat & Livestock Australia Limited.
- Department of Agriculture, Fisheries and Forestry. (2013). *Review of the Australian Standards for the Export of Livestock, Review of the Livestock Export Standards Advisory Group - Final Report 31 May 2013*. Canberra.
- Eccles, R. G., Newquist, S. C., & Schatz, R. (2007). Reputation and Its Risks. *Harvard Business Review*(February 2007), 104-112.
- Farmer, W. (2011). *Independent Review into Australia's Live Export Trade*. Canberra: Report to the Minister for Agriculture, Fisheries and Forestry.

- Francis, P. (2014, April 7). *Live sheep export report unbalanced*. Retrieved from Moffitts Farm: <http://www.moffittsfarm.com.au/2014/04/07/live-sheep-export-report-unbalanced/>
- Gaden, B., Duddy, G., & Irwin, J. (2005). *Identifying live animal condition scoring systems for the Australian livestock export industry*. Sydney: Meat & Livestock Australia.
- Harman, G. S. (1971). Wool and Politics. *Australian Quarterly*, 43, 40-52.
- Haszler, H. (1994). Australia's Wool Policy Debacle: Who Should Pay? *The Australian Quarterly*, 66, 85-100.
- Industry Commission. (1994). *Meat Processing - Volume 1: Report*. Melbourne: Australian Government Publishing Service.
- JBS Australia Pty Ltd. (2018). *Bordertown*. Retrieved from JBS Australia Pty Ltd: <http://www.jbssa.com.au/ourfacilities/processingfacilities/Bordertown/default.aspx>
- Jones, K. G. (2004). *Trends in the U.S. Sheep Industry*. Washington D.C.: United States Department of Agriculture Economics Research Service.
- Keniry, J., Bond, M., Caple, I., Gosse, L., & Rogers, M. (2003). *Livestock Export Review: Final Report - A Report to the Minister for Agriculture, Fisheries and Forestry*. Canberra: Department of Agriculture, Fisheries and Forestry.
- Keogh, M., Henry, M., & Day, N. (2016). *Enhancing the competitiveness of the Australian livestock export industry*. Sydney: Australian Farm Institute.
- Kingwell, R., Cunningham, P., Nath, T., Anderton, L., Xayavong, V., Curis, K., . . . Feldman, D. (2011). *The Economic Importance to Western Australia of Live Animal Exports*. Perth: Department of Agriculture and Food Western Australia.
- Lindner, R., Darcy, M., Fletcher, R., Griffiths, D., Haynes, G., Minton, G., . . . Burggraaf, W. (2004). *Cattle and Sheep Meat Processing in Western Australia: Ministerial Taskforce Final Report November 2004*. Perth: Department of Agriculture Western Australia.
- LiveCorp & Meat & Livestock Australia Limited. (2013). *Australian livestock export industry statistical review 2012*. Sydney.
- Makin, K., House, J., Perkins, N., & Curran, G. (2010). *Investigating mortality in sheep and lambs exported through Adelaide and Portland*. Sydney: Meat & Livestock Australia.
- McCarthy, M. (2018, January 4). *Welding blamed for massive Murray Bridge abattoir fire*. Retrieved from ABC News: <http://www.abc.net.au/news/2018-01-04/murray-bridge-abattoir-fire-impact/9303756>
- Meat & Livestock Australia. (2001). *Making the most of mutton*. North Sydney.
- Meat & Livestock Australia. (2016b, August 22). *Dry ageing expands sheepmeat's place on the menu*. Retrieved from Meat & Livestock Australia: <https://www.mla.com.au/news-and-events/industry-news/dry-ageing-expands-sheepmeats-place-on-the-menu/>
- Meat & Livestock Australia. (2017). *Sheep Assessment Manual*. Sydney.
- Meat & Livestock Australia. (2018). *Australian livestock exports Monthly trade summary December 2017*. Sydney.

- Meat & Livestock Australia Limited. (2015). *Australian livestock export industry statistical review*. Sydney.
- Meat & Livestock Australia Limited. (2016). *Glossary*. Retrieved from Meat & Livestock Australia: <https://www.mla.com.au/general/glossary/>
- Meat & Livestock Australia Limited. (2016a). *Selling options*. Retrieved from Meat & Livestock Australia: <https://www.mla.com.au/research-and-development/preparing-for-market/selling-options/>
- Michalk, D. L. (1990). Sheep Production in Australia. *Rangelands*, 2, 189-191.
- Morris, S. T. (2009). Economics of sheep production. *Small Ruminant Research*, 86, 59–62.
- Norris, R. T., & Norman, G. J. (2013). *National livestock export industry shipboard performance report 2012*. North Sydney: Meat & Livestock Australia Limited.
- Phillips, C. (2016). The welfare risks and impacts of heat stress on sheep shipped from Australia to the Middle East. *The Veterinary Journal*, 218, 78–85.
- Prakash, S. (2016, April 27). *What's the Difference Between Lamb and Mutton?* Retrieved from kitchn: <https://www.thekitchn.com/whats-the-difference-between-lamb-and-mutton-230038>
- Robinson, G. (2007). Live Sheep Export Industry: Past, Present & Future - Clean Green & Ethical? *Industry Forum 2007 Innovations in Animal Production to Meet Consumer Expectations - The University of Western Australia Institute of Agriculture* (p. Thursday 2 August). Perth: Emanuel Exports Pty Ltd.
- Sargison, N. (2008). *Sheep Flock Health: a planned approach*. Oxford: Blackwell Publishing Ltd.
- Schoenian, S. (2015). *Basic information about sheep*. Retrieved from sheep101.info: <http://www.sheep101.info/sheepbasics.html>
- Sheep CRC. (2008). *Taking the mutton out of lamb*. Armidale.
- Thomas Foods International. (2018). *Locations and Facilities*. Retrieved from Thomas Foods International: <http://thomasfoods.com/locations>
- Thomas Foods International. (2018a). Update on Murray Bridge Operations. *Media Release*, 8 January.
- Wong, L., Selvanathan, E. A., & Selvanathan, S. (2015). Modelling the meat consumption patterns in Australia. *Economic Modelling*, 49, 1-10.