Australasian Agribusiness Review
2021, Volume 29, Paper 3
ISSN: 1833-5675

The Benefits of Dry Ageing of Mutton to the Australian Sheep Meat Industry[1]

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Abstract

There is a very large volume of low-value mutton produced in Australia and there have been suggestions that there are value adding opportunities that could improve the returns of sheep meat producers and value chain partners. Dry ageing is one technology being trialled to improve mutton eating quality and so attract premiums from consumer segments with high willingness to pay for guaranteed quality. The objective of this analysis is to estimate the industry-wide benefits of the adoption of dry ageing technology in the Australian mutton market, using assumptions that reflect the most likely ways the technology would be scaled up and most likely supplier and consumer responses in the relevant market segments. A new model of the Australian sheep meat market was used to undertake some scenario analyses about the costs of supplying dry aged mutton ready for delivery to butchers or the hotel, restaurant and institution sector, the size of the target market, and the willingness to pay by consumers for dry aged mutton.

While there are already well-established businesses selling aged meat and there may be other small niche markets where the dry aging technology is profitable, the key result is that only under the most optimistic scenario examined would the implementation of dry ageing of mutton lead to positive industry-wide benefits. For our assumed most likely combination of costs and returns, the loss is around $34,000 per year. This loss is doubled in the pessimistic scenario, and in the optimistic scenario the loss turns into a very small positive return of some $3,600 per year. Sheep farmers gain in all scenarios, but these gains are outweighed in many scenarios by losses to value chain partners (processors, retailers and exporters) and consumers in domestic and export markets. Further experimental work which attempts to better quantify the annual operating cost of the proposed large dry ageing cabinets that ensure quality and the minimisation of moisture loss, and the actual willingness of consumers to pay for mutton of different qualities, in a store setting, may alter this conclusion in the future.

Key words: mutton, dry ageing, industry benefits, equilibrium displacement modelling

[1] Funding for this research was provided by Meat and Livestock Australia through the West Australian Agriculture Authority.

Introduction

Australia accounts for just 6 per cent of the global sheep flock but is the largest exporter of sheep meat (MLA, 2019). In 2018–19, Australia produced almost 501,000 tonnes carcase weight (cwt) of lamb and 230,000 tonnes cwt of mutton, valued at about $4.3 billion (MLA, 2019).

Australia typically processes about 15 million mutton carcases per year; however, in the drought year of 2019, only 9.3 million sheep were slaughtered. The Australian mutton industry is based on surplus sheep from the wool and sheep meat industries. Mutton is derived from older animals, with permanent incisors (teeth). Hoggets, a category within mutton, are animals with one or two permanent incisors, 10–18 months old.

This “by-product” image of mutton means that little effort is put into ensuring that older sheep are suitable for the mutton market. According to White et al. (2001), simple gross margin analysis shows that sheep sales for mutton can be up to 26 per cent of the gross income of sheep producers, but usually it is well below that figure.

Because sheep are not produced in large quantities by many other countries, the mutton market is one in which Australia has relatively little competition. In 2018–19, Australia exported 96 per cent of total Australian mutton production, or over 188,000 tonnes shipped weight (swt). Major markets in 2018-19 were China (39 per cent), the Middle East (15 per cent) and the United States (10 per cent) (MLA, 2019).

With such a high proportion of production exported, domestic consumption of mutton is very small, with domestic disappearance (production minus exports in equivalent units) calculated by MLA as only 0.3 kg/head/year (MLA, 2019). This is roughly 7,500 tonnes cwt per year. Calculations by Mounter et al. (2019) put domestic disappearance at an average of 3,200 tonnes cwt per year for the period 2012-2016 if strictly following the above formula, or up to 11,600 tonnes cwt per year if using a combination of sources of data.

Thus, there is a very large volume of low value mutton available and there have been suggestions that there are value adding opportunities that could improve the returns of sheep meat producers and value chain partners (Herrmann et al., 2017). In the domestic market, even though meat prices are high, there is ample evidence of consumers’ willingness to pay for guaranteed quality through, for example, Meat Standards Australia grading. In export markets, mutton is usually the cheapest source of meat protein available. Therefore, it has the potential, compared to other meats, for development of new markets in developing countries with limited resources. Consumption is very price sensitive and other meats can be easily substituted for it. For example, Jabarin (2005) reported the results of the estimation of a linear approximate almost ideal demand system for meat demand in Jordan, a major market for Australian sheep meat. The results revealed that the demand for mutton and poultry is elastic while the demand for beef and fish is inelastic. The cross-price elasticities indicate that poultry and beef are substitutes for mutton. Conversely, in developing countries with a rapidly expanding middle class, there are said to be opportunities for moving into a different customer segment.

Dry ageing is one technology being trialled to improve mutton eating quality and so attract premiums from consumer segments with high willingness to pay for guaranteed quality.

A value added dry aged mutton industry could develop in a number of ways:

- Abattoirs dry age on site and sell to wholesalers;

- Abattoirs sell fresh mutton to a value adding processor who dry ages and sells to retailers, restaurants and the food service sector; or
- Retailers and/or restaurants dry age in-store.

The objective of this analysis was to estimate the industry-wide benefits of the adoption of dry ageing technology in the Australian mutton market, using assumptions reflecting most likely ways the technology would be scaled up and most likely supplier and consumer responses in the relevant market segments. This is a classic strategic fit decision: is the expected increase in willingness to pay at the retail level sufficient to cover the expected increase in costs required to supply the new marketing services?

In terms of the way the technology could be implemented, we assume that this is done by a value adding processor/wholesaler/food service provider who already provides aged meat to specialist retailers, restaurants and food service companies. Thus, the analysis centres on whether providing dry aged mutton to these clients is more profitable than traditional cool-room aged mutton.

Markets for Mutton

Domestic market

Australian consumption of mutton has declined substantially in recent decades but is currently quite stable at around 0.3kg/head/year according to MLA (2019). There are three main domestic sectors (White et al., 2001; MLA, 2019):

- Manufacturing. Consumption has moved toward manufactured meat products such as processed smallgoods, meat pies, sausage rolls and dim sims;
- Retail. Hoggets are often sold as whole or half carcases through meat retailers. Small quantities of better-quality mutton are also utilised by the retail sector;
- Hotels, restaurants and institutions (HRI). A range of mutton cuts are used in Asian, Indian and Middle Eastern style restaurants and in fast food like doner kebab and souvlaki outlets.

Broad specifications for the domestic market are typically 17–21kg, fat score 1 to 3. Most are lighter sheep, less suitable to the heavy export trade. They are used for smallgoods. Mutton use in this trade is driven by price. However, heavier carcases with good conformation and well finished hoggets are used in the domestic retail and HRI trade. Hogget price is usually 25 per cent higher per kg carcase weight than mutton of export specification.

While there are no official statistics on the shares of the domestic market taken up by these different sectors, White et al. (2001) estimated that “table” mutton constituted only 3 per cent of total domestic consumption.

Export markets

Australian mutton is exported to about 70 countries with a variety of cultures and eating habits. Almost all Australian mutton in both volume and value terms is exported as frozen boxed product.

Light export. Specifications are typically 14–16kg carcase weight, fat score 1 or 2. This is a low value commodity market supplying the Middle East. Some 80 per cent of this market is supplied as frozen whole carcases. Throughout the year, demand varies with climatic conditions in the Middle East.

Heavy export. Specifications are typically more than 20kg carcase weight, fat score 1 to 4. Exporters prefer mutton carcases to be as heavy as possible. Price is usually 25 per cent higher per kg cwt than the domestic market. Heavy carcases reduce processing costs per kg of mutton, as slaughter costs are incurred on a per head basis, achieve higher boning ratios at the same fat level and have more potential for value adding.

Medium weight carcases are broken “6-ways” into legs, middles and forequarters. Six-way mutton is packed 1–1.5 carcases per box and exported to many markets including the United States, Canada, South Africa and Asia.

Occasionally there is a premium for carcases more than 24kg. Heavier carcases may be boned into high value primal cuts from the leg and loin, destined primarily for the European Union.

Hoggets are purchased by exporters at the mutton price as, in contrast to the domestic market, hoggets are not differentiated from mutton in the export market.

Method for Estimation of Industry Benefits

The standard procedure that economists use to evaluate the net economic benefits of a new agricultural technology is as follows:

- first, a model or models of the type of business where the technology will be implemented is solved “with and without” the technology to calculate the economic impact of the new technology. These models are either “representative” models of that type of business, or they are case studies based on actual data from the case study business; and
- second, the results from the model of the representative business are used as inputs into an industry model, with appropriate assumptions about the proportion of the industry ultimately effected and the timeframe for adoption.

For example, to examine the industry benefits of a new pasture technology for milk production, a model of a dairy enterprise (say a whole farm gross margins model) would be solved with and without the new pasture technology, and the net change in whole farm gross margin (presumably positive) would be used as an input into a model of the dairy market. The incentive provided by the increase in expected profitability would induce an increase in output across the industry, with subsequent impacts on prices at different levels of the market and demand for the range of dairy products.

The authors are unaware of any existing published models of meat processing plants or retailing enterprises, anywhere in Australia, that could be updated and/or modified for use to provide a financial assessment of the production of dry-aged sheep meat by an individual sheep meat processing enterprise. In lieu, advice was sought from industry experts about values of key parameters required to produce the types of results necessary to meet the project objective.

At the industry level, evaluation of the net economic benefits from new technology adoption requires a model that is representative of the main elements of the economic structure of the industry or market under consideration and the key linkages between these elements.

The most often-used modelling framework that meets these requirements for agricultural industry analysis of R&D investments is known as “structural” economic modelling. Other modelling options that have been used included optimisation models such as quadratic programming, and systems dynamics models. These do not meet the requirements to the same extent.

The two broad types of structural economic models are econometric models and partial equilibrium models. In both cases, the models are based on well-established microeconomic theory. The industry of interest is represented by a system of demand and supply relationships, price transmission relationships and market clearing conditions, and is calibrated with actual historical data on prices and quantities. The impact of any exogenous change to the system, such as a new technology, is modelled as a shift in a demand curve or a supply curve from the assumed base situation (either the current year, or some representative year). These shifts can occur anywhere in the model, from shifts in farm supply through to shifts in retail demand. Assumptions about producer and consumer responses allow estimates of changes in all market prices and quantities and, based on these, changes in “producer surplus” and “consumer surplus” can be calculated as measures of the gross benefit or cost to the industry from the exogenous change.

Econometric models use time-series data on all of the variables included in the model to estimate parameter values (elasticities) in the demand and supply equations by statistical techniques. Favourable aspects of econometric estimation are that dynamic relationships such as seasonality and time effects can be captured within the simulation. In agriculture, seasonal conditions influence yields of crops and other products and, in livestock production, seasonal conditions that influence breeding decisions and biological constraints may result in time lags between breeding and product sales. Time lags also exist between initial research investment and maximum adoption of a new technology. An example of this type of model is the Vere et al. (2000) quarterly structural econometric model of the Australian grazing industries incorporating the wool, lamb and mutton and beef sectors.

However, as the data series underlying an econometric model are increasingly restricted in both collection and reporting, the maintenance of econometric models that rely on lengthy historical data becomes increasingly difficult. Thus, the data-intensive nature of the Vere et al. (2000) econometric model is prohibitive to its continued use. For this reason, the use of a comparative static approach, more commonly known as ‘Equilibrium Displacement Modelling’ (EDM), to evaluate R&D investments has increased in popularity (Piggott, 1992). Rather than needing historical data spanning decades, EDMs require only base equilibrium price and quantity data before any exogenous changes occur, reflecting a “representative” period of time, and market elasticities to quantify the responsiveness of producers and consumers to changes in market prices. These can be taken from previously published results so do not need to be statistically estimated every time the model is run.

The model can be as simple or as complicated as needed to answer the research questions posed. Typically, the industry structure is specified in considerable detail within the EDM framework. Horizontally, the industries can be disaggregated into different regions (such as for example Western Australia alone, all states individually, or Australia in total), into different products (mutton alone or with lamb, and perhaps with other meats and wool as well) and into different markets, including trading partners. Vertically, the industries can be disaggregated into the various major sectors of the value chain (processors, retailers, consumers).

The partial equilibrium framework of the EDM involves linear approximation of changes in prices and quantities of inputs and outputs arising from new technology (whereas, mentioned above, the net benefits of the technology are first measured in a model of the type of business where the technology will be introduced). These models are static and typically take a medium-term time frame (3-5 years). A limitation of EDM, therefore, is the inability to satisfactorily account for dynamic responses within the modelling framework. However, repeated applications for different lengths of run (using different elasticity values to reflect different degrees of responsiveness) can overcome this deficiency to some extent (Piggott, 1992).

Over the past two decades, a number of standalone EDMs have been developed in relation to Australian agricultural sectors. These include the cattle and beef industries (Zhao et al., 2001a, 2001b, 2003), the sheep and wool industries (Mounter et al., 2008a, 2008b, 2009), the pig industry (Mounter et al., 2005a, 2005b) and the dairy industry (Hill et al., 2001). There are similar models for the grape and wine industry, and simplified models of the dairy and lamb industries that have been used as teaching tools in research organisations. A model for the grains industries has been recently completed (Li et al., 2017).

The models that are available have been applied to questions such as the relative returns from R&D and generic promotion, and the relative returns from on-farm and off-farm R&D. Some of these uses have been in-house advice to government departments and industry bodies such as Meat and Livestock Australia. The models have also been used to answer some specific research questions such as the returns from beef genetics R&D in Australia (Farquharson et al., 2003) and the potential payoffs from a new pork product (Slattery et al., 2010).

Some of the models have been formally updated (Griffith, 2009b; Griffith et al., 2010) and an effort has been made to transform them into versions able to be solved in Excel (Hester and Griffith, 2009). In addition, several technical issues have been considered in some detail. These include the competitive structure of the industry being modelled (Griffith, 2000), the nature and impact of uncertainty about key parameter values (Zhao et al., 2000, 2001b; Mounter et al., 2008b), and economic surplus measurement in multi-market analyses.

There are a number of existing models of the Australian sheep meat industries which could potentially be used in this project. However, the existing econometric model (Vere et al., 2000) is quite dated and, as we have discussed above, some of the time series data needed to update the model are no longer available. An existing DREAM model (Griffith et al., 2009a) (a software package which allows specification of a simplified EDM-style of model) is also dated but requires less input. It could be updated but it could not provide sufficient disaggregation of the vertical market impacts. This leaves us with the existing EDM of the sheep and wool industry (Mounter et al., 2008a). It is also dated and very complicated, and much of the detailed aspects of the model could not be updated.

A new model needed to be designed and constructed to focus on the key parts of the lamb and mutton sectors.

The New Model of the Australian Sheep Meat Industry

The new model was specified, validated, peer-reviewed and published (Mounter, Zhang and Griffith, 2019). Full details are available in the published paper.

The model in algebraic form is reported in Appendix 1. This model was constructed and simulated in a standard econometric simulation package called Time Series Processor, but it can be easily converted into a series of spreadsheets and solved in Excel. The variable definitions and the base parameter values and price and quantity data used to define the initial equilibrium are reported in Appendix 2. A flow chart of the model is provided in Appendix 3.

In the published paper, a number of hypothetical simulation experiments were reported which cover the range of uses of the model: cost reduction in lamb production resulting from any breeding or farm technologies that reduce the cost of producing lambs; cost reduction in mutton production resulting from any breeding or farm technologies that reduce the cost of producing grown sheep; other input cost reductions in lamb processing due to new technologies or management strategies in the processing sector; other input cost reductions in mutton domestic marketing due to new technologies or management strategies in the domestic marketing sector; increase in the willingness to pay by domestic lamb consumers due to lamb promotion or changes in tastes in the domestic market; and Increase in the willingness to pay by export mutton consumers due to mutton promotion or changes in tastes in the export market.

Each of these simulations is implemented by altering one of the supply shift (tx) or demand shift (nx) parameters in the model equations. For example, the first hypothetical simulation experiment assessed a 1 per cent reduction in the cost of lamb production resulting from any breeding or farm technologies. This was implemented by setting the parameter tx1 in equation 1 in Appendix 1 equal to -0.01: a 1 per cent downward shift in the supply curve for lambs.

The results of the various simulation experiments were reported as both the aggregate annual value of the full implementation of the hypothetical technology, and the distribution of this total amount across all the value chain participants, in the lamb, mutton and live sheep sectors. Thus, for the first simulation experiment mentioned above, the total gain in economic surplus from a 1 per cent cost reduction in lamb production is $22.8 million (Mounter et al., 2019), based on the base level price and quantity data used to calibrate the model. Sheep farmers in total receive about 36 per cent of these benefits, other input suppliers (processors, exporters, retailers) receive about 10 per cent, and consumers in aggregate (in both domestic and export markets) receive about 54 per cent. These shares reflect the economic structure of the industry as embedded in the algebraic equations, and the assumed specific parameter values which show the responsiveness of producers, consumers and other value chain participants to price changes.

One result that should be noted is the strong substitutability relationships evident between the lamb and mutton and the mutton and live sheep sectors, and the disconnect between the lamb and live sheep sectors. Thus, in these hypothetical experiments, the mutton industry loses from profitable investments in the lamb industry, and the lamb industry and the live sheep industry lose from profitable investments in the mutton industry.

When we are assessing the industry economic benefits of the dry ageing technology in the mutton sector, we have to select which supply and demand shifters in the algebraic model are the relevant ones to measure the impact of the adoption of the technology, and then use whatever data and information are available to specify changes in these parameter values.

The measures we use to decide whether an industry is better off or worse off after a change such as a new technology are known as “producer surplus” and “consumer surplus”.

In a standard market equilibrium (supply and demand) diagram, producer surplus is measured as the area above the supply curve and below the equilibrium price line. The supply curve is the marginal cost curve for the industry and represents the price at which different producers would be willing to supply. If they receive the higher market price, they are better off. The sum of these differences between actual price and the price at which they were willing to supply, across all producers, is called producer surplus.

Consumer surplus is measured as the area below the demand curve and above the equilibrium price line. The demand curve for the industry represents the price which different consumers would be willing to pay. If they only pay a lower market price, they are better off. Summed across all consumers, these differences between actual price and the price at which they were willing to pay, are called consumer surplus. Total surplus is the sum of producer and consumer surplus. Formulas to estimate producer and consumer surplus areas are contained in the model simulation routine.

Available Data

We assume the most likely way that this technology would be implemented at an industry level is that abattoirs would sell fresh mutton carcases or primals to a value adding processor who dry ages and sells to retailers, restaurants and the food service sector. We further assume this processor would already offer wet aged mutton to these clients, to satisfy their consumers who demand and are willing to pay for aged meat.

Changes in processing cost

There is considerable uncertainty about the capacity of various cool rooms and dry ageing cabinets and how much they cost to operate. The dry ageing experimental work was done using small cabinets with a capacity of 35-40 kg; however, most of the costing data has been supplied by companies that provide commercial cool rooms or that are constructing dry ageing rooms of shipping container size.

A commercial cool room company representative quoted \$10.50/day to run a 3m^2 cool room in summer if power was around \$0.30/kwh, and \$7.50/day in winter. This equates to \$9.00/day, all year round. The dry ageing container (assumed, and shown in photos, to be a standard "20-foot" size) is quoted at a capacity of 4320kgs, but this is about twice the capacity of a 3m*3m cool room. So, \$9.00/day over an assumed 2200kgs is \$0.0041/kg/day in a typical commercial wet ageing cool room. Mutton is typically aged for 14 days to materially impact tenderness; so, over this period the cost is \$0.057/kg of wet aged mutton ready for delivery to butchers or the HRI sector.

The dry ageing commercial company quoted a 35-day ageing cost of \$0.410/kg based on the weight of the meat at the start of the process. However, dry ageing results in significant shrinkage of around 20 per cent, so this cost has to be increased to \$0.51/kg to reflect a kg of dry aged mutton ready for delivery to butchers or the HRI sector.

Based on this comparison, the per kg cost to produce dry aged mutton instead of wet aged mutton is almost 10 times higher. This is made up of substantially higher power usage (168 Kwh/day compared to 36Kwh/day) and more than double the length of ageing time required, even though some economies would be gained from the higher capacity of the dry ageing container.

University of Melbourne researchers (Hastie and Warner, 2019) used smaller cabinets for their experimental work and noted that, if the meat is cut as primals or sub-primals, a capacity of 35-40kgs would be appropriate. Based on power consumption data for cabinets of this size provided by commercial suppliers, they estimated a cost of \$0.105/kg for wet aged mutton over a 14-day period, and a cost of \$0.51/kg for dry aged mutton over a 35-day period.

The cost/kg for dry ageing is consistent across different sizes, but the cost of wet ageing does vary according to the size of the cool room used. Here, we assume the commercially available, and cheaper, option would be used. Hence, there is a \$0.45/kg cost difference to produce a kg of dry aged mutton instead of a kg of wet aged mutton, ready for delivery to butchers or the HRI sector.

In terms of model inputs (Appendix 3), the cost of supplying other mutton domestic marketing inputs (ew12) is the difference between the base retail mutton price (\$9.33/kg) and the base wholesale mutton carcase price (\$3.22/kg), or \$6.11/kg. This cost has to be increased by \$0.45c/kg for that proportion of domestic consumption that is considered to be the target market for this technology.

Another consideration is that industry experts have stated that extra boning costs of approximately 50 per cent are required for 35-day dry aged meat compared to wet aged meat. We have no explicit information on the share of boning costs in the \$6.11/kg cost of supplying other domestic marketing inputs. We assume it is a similar value to the extra costs of ageing, so an additional \$0.45/kg.

To represent this change, we use the supply function for other mutton domestic marketing inputs (equation 33 in Appendix 1), which contains the shifter parameter tx12. We specify tx12=0.147*(specified market share) (see below). Since this shift represents an increase in costs, it is an upward shift, and so is a positive number.

Changes in willingness to pay

The experimental work done at the University of Melbourne compared two primals (topside and loin), two ageing treatments (wet and dry) and four ageing periods (14, 28, 42, 56 days). The results were summarised in Hastie and Warner (2019). The results have been aggregated in different ways, which makes it difficult to pull out the specific dry vs wet ageing comparisons.

To summarise the results, about two thirds of all subsets of consumers ranked dry aged mutton above wet aged mutton on actual eating quality scores, across ageing period and type of primal. These differences were significant for consumers of British and European descent. When all these scores are aggregated and compared, the score for dry ageing was 66.22 while the score for wet aging was 63.73, a 3.9 per cent increase.

Another strong result was that, for some eating quality measures, the scores improved with ageing, at least up until 35 days.

Finally, the eating quality scores provided by consumers were always much better for the loin ("better than everyday quality") than for the topside ("good everyday quality"). When these scores were standardised on a 4-point scale, where 3 was the standard for "good everyday quality" and 4 was the standard for "better than everyday quality", the mean scores across ageing treatments and ageing periods were 3.85 for the loin and 3.19 for the topside. These consumers stated they were willing to pay \$18.90/kg for "good everyday quality" and \$27.04/kg for "better than everyday quality".

Therefore, the loin would be the mutton primal to put through dry ageing as it ranks much higher than the leg, 35 days seems to be a consistent midpoint in the ageing period profile where improvements can be seen, and consumers prefer dry ageing to wet ageing and are willing to pay more for it.[2]

In terms of model inputs (Appendix 3), the base retail mutton price is set at \$9.33/kg. This is a weighted average of the per kg value in all the uses of mutton in the domestic market that is contained within the estimated 0.3kg/capita/year (around 7,500 tonnes cwt), ranging from various processing uses to wet aged mutton for butchers and the HRI sector. What we have to do is work out from the information above a shift parameter for the domestic mutton retail demand function that reflects the higher eating quality of dry aged mutton compared to wet aged mutton and consumers' willingness to pay for this quality improvement.

[2] However, dry ageing makes the loin smaller than wet ageing and with older animals the skin is very tough, making it difficult to achieve the right degree of doneness. For these animals, the chefs involved in the experimental work decided the best way to use loin was to grind it for a high-quality mince or burger patty. In restaurants there is a niche for this type of meal but it requires extra work. The best eating cuts were the rump and shoulder, particularly if slow cooked.

If we just focus on the loin, the mean score of 3.85 is an average of both dry and wet age treatments. Given consistency between consumers' reported actual eating scores and the standardised scores, we can use the result that dry aged is 3.9 per cent higher in actual scores. So, we assume that for loin, the standardised score would be 3.93 for dry ageing and 3.77 for wet ageing. At the quoted willingness to pay values, 3.93 would represent $26.47/kg as willingness to pay for dry aged mutton, while 3.77 would represent $25.16/kg as willingness to pay for wet aged mutton. This is a 5.2 per cent increase.

To represent this change we use the demand function for mutton at retail (equation 37 in Appendix 1), which contains the shifter parameter nx16. We specify nx16=0.052*(specified market share). Since this shift represents an increase in willingness to pay, it is an upward shift, and so is a positive number.

It is noted that shelf life[3] is expected to be shorter with dry ageing, but this information is assumed to be known within the industry and that appropriate ordering policies and logistics would be in place. The economic question, therefore, is whether the 5.2 per cent increase in willingness to pay at the retail level ($1.31/kg) is sufficient to cover the 14.7 per cent increase in the costs of supplying other mutton domestic marketing services ($0.90/kg), after adoption across the specified market segment and after all of the related suppliers and consumers have responded to the initial disequilibrium.

Proportion of domestic consumption

The final key assumption relates to the proportion of domestic consumption that is considered to be the target market for the dry ageing technology.

It was reported above that the domestic mutton market is small overall (ranging from 3,200 to 7,500 to 11,600 tonnes cwt, depending on how it is calculated (MLA, 2019; Mounter et al., 2019)) and is made up of three main sectors: manufacturing, retail and hotels, restaurants and institutions (HRI). Small quantities of better-quality mutton are utilised by the retail sector, and a range of mutton cuts are used in Asian, Indian and Middle Eastern style restaurants. These might be the outlets where the target market for dry aged mutton would be found. Unfortunately, there are no official statistics on the shares of the domestic market taken up by these different sectors, although White et al. (2001) estimated at that time that "table" mutton constituted only 3 per cent of total domestic consumption.

If the retail and HRI market for mutton in total (excluding hogget) was 10 per cent, and we only consider the middle primals, then the target market may be quite close to the 3 per cent figure quoted by White et al. (2001). Therefore, the specified market share parameter that goes into the formulas for the tx12 supply shifter and the nx16 demand shifter is 0.033.

To summarise, for this scenario of the most likely combination of assumptions about shifts in various curves,

tx12=0.147*0.033=0.0049, and

nx16=0.052*0.033=0.0017.

Alternate Scenarios

[3] Dry aged meat (done properly) has a better bacterial profile than wet aged meat. However, after ageing the colour characteristics are not likely to be as good once sliced for retail display and will probably go brown quickly, reducing shelf life. There is debate as to whether the meat can be put into cryovac after dry ageing as this brings moisture out of the meat to the surface. Presentation in a supermarket could be problematic unless it has a high-end butchery section.

Given the considerable uncertainty about how this technology would be implemented in the sheep meat industry and how the consumers of various types of sheep meat products would react to this new product, two alternate scenarios were developed, one “pessimistic” and one “optimistic”.

Pessimistic

Compared to the assumptions made in the most likely case, this scenario assumes a 20 per cent increase in the costs of supplying dry aged mutton ready for delivery to butchers or the HRI sector, and a 20 per cent decrease in the willingness to pay by consumers for dry aged mutton.

Thus,

tx12=0.177*0.033=0.0058, and

nx16=0.042*0.033=0.0014.

Optimistic

Compared to the assumptions made in the most likely case, this scenario assumes a 20 per cent saving in the costs of supplying dry aged mutton ready for delivery to butchers or the HRI sector, and a 20 per cent increase in the willingness to pay by consumers for dry aged mutton.

Thus,

tx12=0.118*0.033=0.0039, and

nx16=0.062*0.033=0.0020.

Size of domestic market

The size of the target market is simply a linear scaling factor so, if it was assumed to be 20 per cent smaller or 20 per cent larger, the aggregate annual benefits (or losses) would just be 20 per cent higher or lower. The distribution of the benefits (or losses) would be assumed to be unchanged. However, given the wide disparity in the various estimates available about the size of the domestic market for mutton, it was considered worthwhile to formally model these alternatives, in combination with the three scenarios for implementation. Thus, the optimistic, most likely and pessimistic scenarios are run for domestic markets of 3,200, 7,500, and 11,600, tonnes cwt.

Results

The full results of the nine simulation experiments are reported in Tables 4.1, 4.2 and 4.3 in Appendix 4. A summary is provided in Table 1.

The striking result is that only under the most optimistic scenarios examined would the implementation of dry ageing of mutton lead to positive industry wide benefits. For our assumed most likely combination of costs and returns, and the mid-range estimate of the size of the domestic mutton market, the loss is around $34,000 per year. This loss is doubled in the pessimistic scenario, and in the optimistic scenario the loss turns into a very small positive return of some $3,600 per year. It is apparent that this value is economically insignificant when compared to the value of mutton sold at retail (some $47.5 million, based on the information in Table A2.3).

As expected, running the scenarios under different assumptions about the size of the domestic market shows that the size of the assumed target market is simply a scaling factor. If the target market was larger under the optimistic scenario the benefits would be proportionally higher, but if the most likely or pessimistic scenarios prevailed the losses would be proportionally greater. The converse would be the case if the target market was smaller than assumed.

Sheep farmers gain in all scenarios, but these gains are outweighed by losses to consumers in domestic and export markets. Value chain partners (processors, retailers and exporters) also gain in the two smaller market scenarios but lose in the larger market scenario.

The estimated changes in total surplus across the whole sheep meat industry are exactly mirrored in the mutton sector, where mutton producers only gain in the most optimistic scenario and mutton consumers in aggregate lose in all cases. For the lamb and live sheep sectors, the gains in surplus to farmers are exactly offset by losses to consumers and value chain sub-sectors.

Table 1. Economic surplus changes (in $million per year) to various industry groups from alternative scenarios and alternative estimates of the size of the domestic market for mutton

Estimated Size of the Domestic Mutton Market (tonnes cwt)	Industry Group	Pessimistic Scenario (tx12=0.0058; nx16=0.0014)	Most Likely Scenario (tx12=0.0049; nx16=0.0017)	Optimistic Scenario (tx12=0.0039; nx16=0.0020)
3,200	Farmers	0.0628	0.0418	0.0193
	Other Input Suppliers	0.0096	0.0058	0.0019
	Consumers	-0.1019	-0.0622	-0.0196
	Total Industry	**-0.0295**	**-0.0146**	**0.0016**
7,500	Farmers	0.0525	0.0386	0.0231
	Other Input Suppliers	0.0033	0.0019	0.0014
	Consumers	-0.1252	-0.0743	-0.0209
	Total Industry	**-0.0694**	**-0.0338**	**0.0036**
11,600	Farmers	0.0440	0.0357	0.0266
	Other Input Suppliers	-0.0034	-0.0020	-0.0009
	Consumers	-0.1482	-0.0903	-0.0202
	Total Industry	**-0.1076**	**-0.0566**	**0.0055**

Discussion and Conclusions

The economic question that we asked earlier was whether the assumed 5.2 per cent increase in willingness to pay at the retail level ($1.31/kg) was sufficient to cover the 14.7 per cent increase in the costs of supplying other mutton domestic marketing services ($0.90/kg), after adoption across the specified market segment and after all of the related suppliers and consumers have responded to the initial disequilibrium.

The answer is “no”, except under the most optimistic combination of assumptions, and then basically only to a breakeven level.

The answer may well be “yes” on an individual business basis, but once sufficient volumes of mutton are aged and offered to the market so that market prices are impacted, and once sheep farmers, value chain partners and consumers have time to respond to those different prices, the initial benefit is bid away and the industry as a whole is worse off when WTP incentives are not sufficient to offset the increased costs.

In the pessimistic and most likely scenarios, the higher cost of producing dry aged mutton, even when averaged across the whole domestic market volume, drives a wedge between retail and farm prices for mutton. Farm prices for mutton fall and producers respond by reducing supply. With lower volumes and lower prices, mutton farmers and their value chain partners are worse off – producer surplus is reduced. Mutton consumers in both the domestic and export markets face higher prices and they reduce consumption, so they too are worse off – consumer surplus is reduced. In these two scenarios the impact of the higher WTP for dry aged mutton in the domestic market is not sufficient to overcome the cost effect. One minor benefit is that some of the mutton destined for slaughtering is diverted to the live sheep trade, so live sheep consumers are better off.

In the optimistic scenario the opposite happens. The higher cost of producing dry aged mutton still drives a wedge between retail and farm prices for mutton, but here the impact of the higher WTP for dry aged mutton in the domestic market is sufficient to (just) overcome the cost effect. Higher retail prices pull up farm prices for mutton and producers respond by increasing supply. With higher volumes and higher prices, mutton farmers and their value chain partners are better off – producer surplus is increased. Mutton consumers in the domestic market face higher prices and they reduce consumption, so they are still worse off – consumer surplus is reduced, but increased quantities are diverted to the export market so export consumers are better off.

We noted previously the strong substitutability relationships evident between the lamb and mutton and the mutton and live sheep sectors, and the disconnect between the lamb and live sheep sectors. Thus, the mutton industry loses from profitable investments in the lamb industry, and the lamb industry and the live sheep industry lose from profitable investments in the mutton industry. The results shown in Appendix 4 confirm these effects. In the pessimistic and most likely scenarios (unprofitable investments in the mutton industry), lamb farmers gain and live sheep farmers lose.

And recall, we are not talking about large volumes here. If we accept MLA's estimate of the total size of the domestic market at around 7,500 tonnes, for all uses, then the assumed 3.3 per cent as "table" mutton is less than 250 tonnes. The specified container-sized dryer has a capacity of 4.3 tonnes every five weeks or 43 tonnes per year. Thus, only six of these dryers would provide all of the dry aged mutton that is required. But even on these small amounts, the specified changes in costs and changes in willingness to pay are sufficient to disrupt the market.

One thing not yet considered is the investment required to set up a dry ageing business as assumed above. The capital cost of the specified container-sized dryer has been quoted at approximately $100,000. Even in the current, very low, interest rate environment, and with a generous economic life of 20 years, at least $15,000 additional revenue would be required every year just to cover the opportunity cost of the capital and routine repairs and maintenance, for each container. The simulation results do not support this level of additional revenue.

Further, all models by definition are "a representation of reality". Some elements of the specification of the aggregate sheep meat model used here do not lend themselves perfectly to this type of differentiated market analysis. For example, in the model, mutton is mutton is mutton, of similar quality and value in all uses. However, it would be a major undertaking to respecify and recalibrate the model to include different mutton products when there are no accessible data on the markets for these alternatives.

To conclude on a positive note, there are already well-established businesses selling aged meat (for example https://www.vicsmeat.com.au/our-meat) and there may be other small niche markets where the dry aging technology is profitable. The assumed 5.2 per cent increase in willingness to pay at the retail level ($1.31/kg) is sufficient to cover the 14.7 per cent increase in the costs of supplying other mutton domestic marketing services ($0.90/kg), if the volumes of mutton aged are not large enough to impact on market prices. These possibilities cannot be revealed given the type of model used here to calculate benefits.

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Appendix 1. Model Equations in Displacement Form

1 Supply of lambs

ex1-ipx1*(ew1-tx1)

2 Supply of other lamb slaughtering and processing inputs

ex3-ipx3*(ew3-tx3)

3-4 Input-constrained output supply functions for the lamb slaughtering and processing sector

ex5+(rx7*taux5x7)*ew5-rx7*taux5x7*ew7-ezl

ex7-(rx5*taux5x7)*ew5+rx5*taux5x7*ew7-ezl

5-6 Output-constrained input demand functions for the lamb slaughtering and processing sector

ex1+kx3*sigx1x3*ew1-kx3*sigx1x3*ew3-eyl

ex3-kx1*sigx1x3*ew1+kx1*sigx1x3*ew3-eyl

7-8 Equilibrium conditions for the lamb slaughtering and processing sector

kx3*ex3+kx1*ex1-rx5*ex5-rx7*ex7

kx3*ew3+kx1*ew1-rx5*ew5-rx7*ew7

9 Supply of other lamb export marketing inputs

ex9-ipx9*(ew9-tx9)

10-11 Output-constrained input demand functions for lamb export marketing

ex5+kx9*sigx5x9*ew5-kx9*sigx5x9*ew9-ex13

ex9-kx5*sigx5x9*ew5+kx5*sigx5x9*ew9-ex13

12 Equilibrium condition for lamb export marketing

ew13-kx5*ew5-kx9*ew9

13 Export demand for lamb

ex13-itx13*(ew13-nx13)

14 Supply of other lamb domestic marketing inputs

ex11-ipx11*(ew11-tx11)

15-16 Output-constrained input demand functions for lamb domestic marketing

ex7+kx11*sigx7x11*ew7-kx11*sigx7x11*ew11-ex15

ex11-kx7*sigx7x11*ew7+kx7*sigx7x11*ew11-ex15

17 Equilibrium condition for lamb domestic marketing

ew15-kx7*ew7-kx11*ew11

18 Demand for domestic lamb

ex15-itx15*(ew15-nx15)-itx15x16*(ew16-nx16)

19-20 Supply of mutton

qx2*ex2+qx17*ex17-ipx2*ew2+ipx2*tx2

ew17-tx17-ipx*ew2+ipx1*tx2

21 Supply of other mutton slaughtering and processing inputs

ex4-ipx4*(ew4-tx4)

22-23 Input-constrained output supply functions for the mutton slaughtering and processing sector

ex6+(rx8*taux6x8)*ew6-rx8*taux6x8*ew8-ezm

ex8-(rx6*taux6x8)*ew6+rx6*taux6x8*ew8-ezm

24-25 Output-constrained input demand functions for the mutton slaughtering and processing sector

ex2+kx4*sigx2x4*ew2-kx4*sigx2x4*ew4-eym

ex4-kx2*sigx2x4*ew2+kx2*sigx2x4*ew4-eym

26-27 Equilibrium conditions for the mutton slaughtering and processing sector

kx4*ex4+kx2*ex2-rx6*ex6-rx8*ex8

kx4*ew4+kx2*ew2-rx6*ew6-rx8*ew8

28 Supply of other mutton export marketing inputs

ex10-ipx10*(ew10-tx10)

29-30 Output-constrained input demand functions for the mutton export marketing sector

ex6+kx10*sigx6x10*ew6-kx10*sigx6x10*ew10-ex14

ex10-kx6*sigx6x10*ew6+kx6*sigx6x10*ew10-ex14

31 Equilibrium condition for the mutton export marketing sector

ew14-kx6*ew6-kx10*ew10

32 Export demand for mutton

ex14-itx14*(ew14-nx14)

33 Supply of other mutton domestic marketing inputs

ex12-ipx12*(ew12-tx12)

34-35 Output-constrained input demand functions for the mutton domestic marketing sector

ex8+kx12*sigx8x12*ew8-kx12*sigx8x12*ew12-ex16

ex12-kx8*sigx8x12*ew8+kx8*sigx8x12*ew12-ex16

36 Equilibrium condition for the mutton domestic marketing sector

ew16-kx8*ew8-kx12*ew12

37 Demand for domestic mutton

ex16-itx16*(ew16-nx16)-itx16x15*(ew15-nx15)

38 Supply of other live sheep export marketing inputs

ex18-ipx18*(ew18-tx18)

39-40 Output-constrained input demand functions for the live sheep export marketing sector

ex17+kx18*sigx17x18*ew17-kx18*sigx17x18*ew18-ex19

ex18-kx17*sigx17x18*ew17+kx17*sigx17x18*ew18-ex19

41 Equilibrium condition for the live sheep export marketing sector

ew19-kx17*ew17-kx18*ew18

42 Live sheep export demand

ex19-itx19*(ew19-nx19)

Appendix 2. Variable Definitions and Base Data and Parameter Values

Table A2.1. Definitions of price and quantity variables in the model

X1 farm quantity of lamb, X2 farm quantity of mutton, X3 lamb processing inputs, X4 mutton processing inputs, X5 quantity of processed export lamb, X6 quantity of processed export mutton, X7 quantity of processed domestic lamb, X8 quantity of processed domestic mutton, X9 lamb export marketing inputs, X10 mutton export marketing inputs, X11 lamb domestic marketing inputs, X12 mutton domestic marketing inputs, X13 quantity of export lamb, X14 quantity of export mutton, X15 quantity of domestic lamb, X16 quantity of domestic mutton, X17 farm quantity of live sheep, X18 live sheep marketing inputs, X19 quantity of live sheep exports.	W1 farm price of lamb, W2 farm price of mutton, W3 price of lamb processing inputs, W4 price of mutton processing inputs, W5 price of processed export lamb, W6 price of processed export mutton, W7 price of processed domestic lamb, W8 price of processed domestic mutton, W9 price of lamb export marketing inputs, W10 price of mutton export marketing inputs, W11 price of lamb domestic marketing inputs, W12 price of mutton domestic marketing inputs, W13 price of export lamb, W14 price of export mutton, W15 price of domestic lamb, W16 price of domestic mutton, W17 farm price of live sheep, W18 price of live sheep marketing inputs, W19 price of live sheep exports.

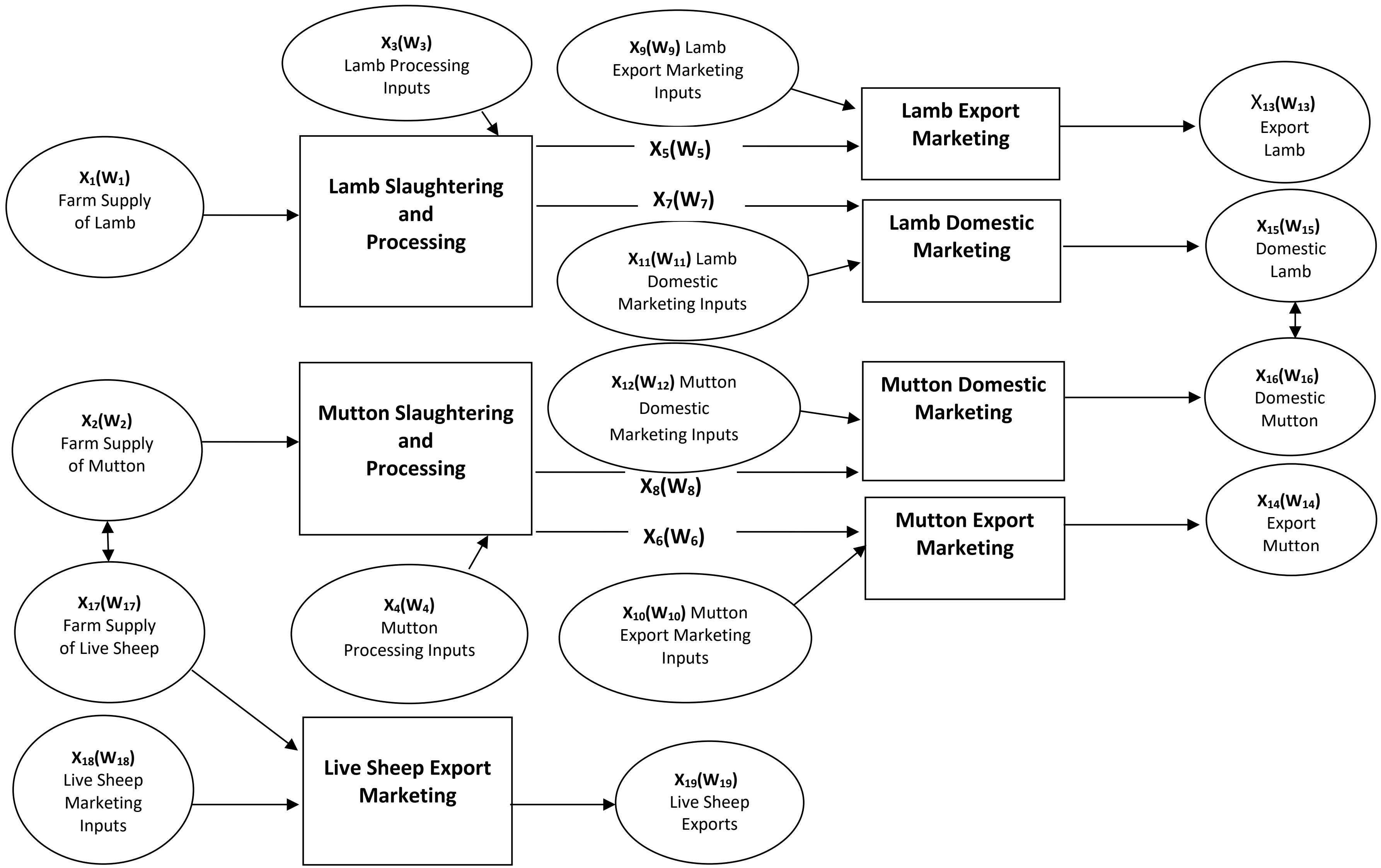
Table A2.2. Base elasticity values in the model

own-price elasticity of supply for lamb.
ipx1=1.5;
ipx3=2.0;
ipx9=5.0;
ipx11=5.0;
own-price elasticity of supply for mutton.
ipx2=1.0;
ipx4=2.0;
ipx10=5.0;
ipx12=5.0;
ipx18=2.0;
price transmission elasticity (mutton/live sheep).
ipx=0.74;
elasticity of substitutability of inputs in lamb processing and distribution
sigx1x3=0.1;
sigx5x9=0.1;
sigx7x11=0.1;
elasticity of substitutability of inputs in mutton processing and distribution
sigx2x4=0.1;
sigx6x10=0.1;
sigx8x12=0.1;
sigx17x18=0.1;
elasticity of transformation of lamb outputs
taux5x7=-0.1;
elasticity of transformation of mutton outputs
taux6x8=-0.1;
own-price elasticity of demand for lamb and mutton
itx13=-2.5;
itx15=-1.0;
itx14=-5.00;
itx16=-0.90;
itx19=-2.00;
cross-price elasticities of demand between lamb and mutton
itx15x16=0.13;
itx16x15=0.50;

Table A2.3. Base equilibrium prices, quantities and revenue and cost shares (average of 2012-2016)

	Quantity and Price	**Cost and Revenue Shares**
Final Sheep Products	<u>Export Sheep Meat</u> (in tonnes and *\$/kg*, shipped weight, TV=\$m)**:** X_{13}=223,105 W_{13}=6.81 TV_{13}=1,519 X_{14}=149,571 W_{14}=4.41 TV_{14}=660 TV_{13+14}=2,179 <u>Export Live Sheep</u> (in tonnes and *\$/kg*, carcass weight, TV=\$m)**:** X_{19}=48,714 W_{19}=4.70 TV_{19}=229 <u>Domestic Sheep Meat</u> (in tonnes and *\$/kg*, retail cuts, TV=\$m)**:** X_{15}=141,799 W_{15}=13.5 TV_{15}=1,914 X_{16}= 2,176 W_{16}=9.33 TV_{16}=20 TV_{15+16}=1,934	<u>Export Marketing Revenue Shares:</u> γ_{X13}=0.63 γ_{X14}=0.27 γ_{X19}=0.10 <u>Domestic Marketing Revenue Shares:</u> γ_{X15}=0.99 γ_{X16}=0.01
Wholesale Carcass	<u>Export Sheep Carcass</u> (in tonnes and *\$/kg*, carcass weight): X_5 =276,345 W_5=5.00 TV_5=1,382 X_6 =189,200 W_6=3.22 TV_6=609 TV_{5+6} =1,991 <u>Domestic Sheep Carcass</u> (in tonnes and *\$/kg*, carcass weight): X_7=208,529 W_7 =5.00 TV_7=1,043 X_8=3,200 W_8 =3.22 TV_8=10 TV_{7+8}=1,053	<u>Export Marketing Cost Shares:</u> k_{X5}=0.91 k_{X9}=0.09 k_{X6}=0.92 k_{X10}=0.08 k_{X17}=0.62 k_{X18}=0.38 <u>Domestic Marketing Cost Shares:</u> k_{X7}=0.54 k_{X11}=0.46 k_{X8}=0.51 k_{X12}=0.49 <u>Processing Revenue Shares</u> γ_{X5}=0.56 γ_{x6}=0.98 γ_{X7}=0.43 γ_{x8}=0.02
Live Sheep	<u>Export Live Sheep</u> (in tonnes and *\$/kg*, carcass weight, TV=\$m): X_{17}=48,714 W_{17}=2.90 TV_{17}=141 <u>Domestic Live Sheep</u> (in tonnes and *\$/kg*, carcass weight, TV=\$m): X_1=484,874 W_1=4.69 TV_1=2,274 X_2=192,400 W_2= 2.90 TV_2=558 TV_{1+2} =2,832	<u>Processing Cost Shares</u> k_{X1}=0.94 k_{X2}=0.90 k_{X3}=0.06 k_{X4}=0.10

Appendix 3. Structure of the Australian Sheep Meat Equilibrium Displacement Model



Appendix 4. Alternate Assumptions about Domestic Mutton Consumption

Table A4.1. Economic surplus changes (in $million) to various industry groups from alternative scenarios (apparent disappearance = 3,200t cwt)

Industry Group	**Pessimistic Scenario (tx12=0.0058; nx16=0.0014)**	**Most Likely Scenario (tx12=0.0049; nx16=0.0017)**	**Optimistic Scenario (tx12=0.0039; nx16=0.0020)**
	$m	$m	$m
Lamb farmers	0.0740	0.0455	0.0150
Mutton farmers	-0.0095	-0.0031	0.0036
Live sheep farmers	-0.0017	-0.0006	0.0007
Farmers subtotal	**0.0628**	**0.0418**	**0.0193**
Lamb processors	0.0014	0.0009	0.0003
Mutton processors	-0.0005	-0.0002	0.0002
Lamb exporters	0.0008	0.0005	0.0002
Mutton exporters	-0.0006	-0.0002	0.0002
Live sheep exporters	0.0004	0.0001	-0.0002
Lamb retailers	0.0122	0.0075	0.0025
Mutton retailers	-0.0041	-0.0028	-0.0013
Other input suppliers subtotal	**0.0096**	**0.0058**	**0.0019**
Overseas lamb consumers:	0.0076	0.0047	0.0015
Overseas mutton consumers	-0.0032	-0.0010	0.0012
Domestic lamb consumers	-0.0960	-0.0591	-0.0194
Domestic mutton consumers	-0.0116	-0.0072	-0.0024
Live sheep consumers	0.0013	0.0004	-0.0005
Consumers subtotal	**-0.1019**	**-0.0622**	**-0.0196**
Total Surplus	**-0.0295**	**-0.0146**	**0.0016**
Mutton sector	**-0.0295**	**-0.0145**	**0.0015**
Lamb sector	**0.0000**	**0.0001**	**0.0001**
Live sheep sector	**0.0000**	**0.0001**	**0.0000**

Table A4.2. Economic surplus changes (in $million) to various industry groups from alternative scenarios (apparent disappearance = 7,500t cwt)

Industry Group	Pessimistic Scenario (tx12=0.0058; nx16=0.0014)	Most Likely Scenario (tx12=0.0049; nx16=0.0017)	Optimistic Scenario (tx12=0.0039; nx16=0.0020)
	$m	$m	$m
Lamb farmers	0.0772	0.0466	0.0137
Mutton farmers	-0.0209	-0.0068	0.0080
Live sheep farmers	-0.0038	-0.0012	0.0014
Farmers subtotal	**0.0525**	**0.0386**	**0.0231**
Lamb processors	0.0015	0.0009	0.0013
Mutton processors	-0.0015	-0.0005	0.0006
Lamb exporters	0.0009	0.0005	0.0001
Mutton exporters	-0.0019	-0.0004	0.0005
Live sheep exporters	0.0010	0.0003	-0.0004
Lamb retailers	0.0132	0.0077	0.0023
Mutton retailers	-0.0099	-0.0066	-0.0030
Other input suppliers subtotal	**0.0033**	**0.0019**	**0.0014**
Overseas lamb consumers:	0.0080	0.0049	0.0014
Overseas mutton consumers	-0.0072	-0.0024	0.0027
Domestic lamb consumers	-0.1003	-0.0605	-0.0178
Domestic mutton consumers	-0.0285	-0.0172	-0.0051
Live sheep consumers	0.0028	0.0009	-0.0011
Consumers subtotal	**-0.1252**	**-0.0743**	**-0.0209**
Total Surplus	**-0.0694**	**-0.0338**	**0.0036**
Mutton sector	**-0.0699**	**-0.0339**	**0.0037**
Lamb sector	**0.0005**	**0.0001**	**0.0001**
Live sheep sector	**0.0000**	**0.0000**	**-0.0001**

Table A4.3. Economic surplus changes (in $million) to various industry groups from alternative scenarios (apparent disappearance = 11,600t cwt)

Industry Group	Pessimistic Scenario (tx12=0.0058; nx16=0.0014)	Most Likely Scenario (tx12=0.0049; nx16=0.0017)	Optimistic Scenario (tx12=0.0039; nx16=0.0020)
	$m	$m	$m
Lamb farmers	0.0803	0.0477	0.0128
Mutton farmers	-0.0308	-0.0102	0.0117
Live sheep farmers	-0.0055	-0.0018	0.0021
Farmers subtotal	**0.0440**	**0.0357**	**0.0266**
Lamb processors	0.0015	0.0009	0.0002
Mutton processors	-0.0028	-0.0009	0.0011
Lamb exporters	0.0009	0.0005	0.0001
Mutton exporters	-0.0019	-0.0006	0.0007
Live sheep exporters	0.0014	0.0005	-0.0005
Lamb retailers	0.0132	0.0079	0.0021
Mutton retailers	-0.0157	-0.0103	-0.0046
Other input suppliers subtotal	**-0.0034**	**-0.0020**	**-0.0009**
Overseas lamb consumers:	0.0083	0.0049	0.0013
Overseas mutton consumers	-0.0106	-0.0075	0.0040
Domestic lamb consumers	-0.1042	-0.0619	-0.0166
Domestic mutton consumers	-0.0458	-0.0272	-0.0073
Live sheep consumers	0.0041	0.0014	-0.0016
Consumers subtotal	**-0.1482**	**-0.0903**	**-0.0202**
Total Surplus	**-0.1076**	**-0.0566**	**0.0055**
Mutton sector	**-0.1076**	**-0.0567**	**0.0056**
Lamb sector	**0.0000**	**0.0001**	**-0.0001**
Live sheep sector	**0.0000**	**0.0001**	**0.0000**