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THE INFLUENCE OF WEIGHT AND FAT ON LAMB PRICES REVISITED

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ABSTRACT

Previous research has found inconsistencies in the valuation of weight and fat characteristics of lamb carcasses between the saleyard and wholesale markets. In this paper, recent New South Wales saleyard and wholesale price data on different classes of lamb are analysed using hedonic methods to determine the relative influence of weight and fat on prices received. Fat score 2 lambs are heavily discounted relative to fat score 3 lambs, and there are significant seasonal price differentials, but there are no significant premiums or discounts for weight or other fat characteristics. These results hold for both the saleyard and wholesale markets. The implication is that the efficiency of price discovery in the Australian lamb market has improved a little in recent years in the sense that premiums and discounts are now consistent across market levels. However consumers' stated preferences for large lean lambs are not being reflected in price incentives generated in the live lamb and lamb carcass markets.

Keywords: lamb, marketing, hedonic models, carcass characteristics

1. INTRODUCTION

The Australian lamb industry has changed dramatically over the last decade[1]. Since 1995, the number of lambs slaughtered has risen 27 per cent and carcass weight has risen 18 per cent so that the quantity of lamb produced has risen by more than 50 per cent (MLA 2007). Most of this extra output has been sold on export markets, exports having risen by two and half times the 1995 volume. This follows the introduction of the "large, lean lamb" program in the early 1990s (MRC 1992, Mullen and Alston 1994, Griffith *et al*. 1995). The range of export markets has expanded as have the types and qualities of lambs required. Australia is now one of the leading lamb producers in the world, and the second largest exporter of lamb. As well, there has been a concerted effort to improve the quality of lamb sold on the domestic market and a Meat Standards Australia scheme for sheep meat has been introduced.

Lamb prices received by producers are now driven by movements in export demands and exchange rates as well as by local pasture and seasonal conditions and economic conditions in the domestic meat market. While producers are unable to influence those factors determined in the rest of the economy, they can have some influence over the type of lamb produced. It is important then that price signals are efficiently transmitted through the lamb market so that there are

[1] Lambs are generally described as; male or female lambs with no 'ram like' characteristics, generally weaned, shorn, having no permanent teeth and normally older than five months of age.

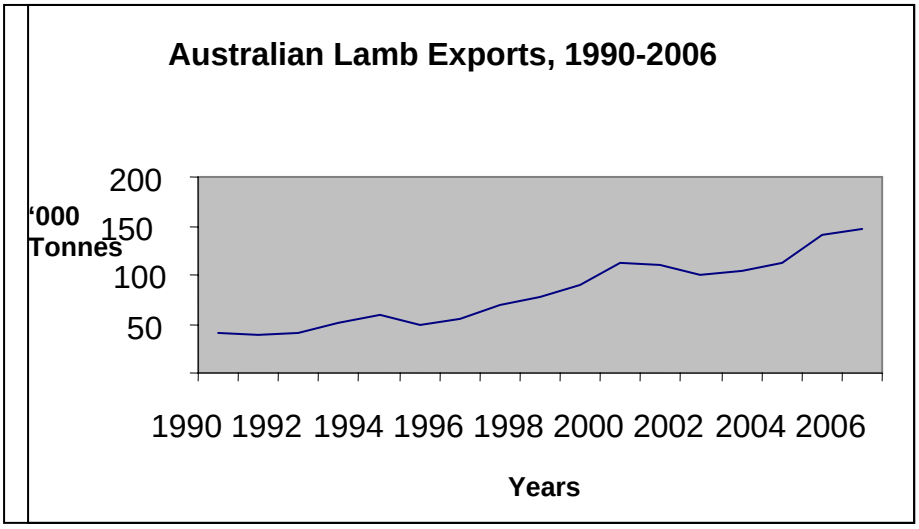
appropriate incentives to produce those quality characteristics demanded by consumers in domestic and export markets. Understanding how lamb prices are determined, and what characteristics contribute to these prices, can be valuable to both buyers and producers. However, little research has been conducted on this issue in recent years. Mullen (1995) undertook a study on the influence of weight and fat score on the price of lamb in the Homebush livestock and wholesale markets, but his study used data that is now quite old. This present study uses the latest data available to update the literature on this aspect of the Australian lamb market.

2. THE AUSTRALIAN LAMB INDUSTRY

Australia is one of the world's leading lamb producers, and the second largest exporter of lamb. In 2005/06 Australia produced 381,800 tonnes of lamb, with New South Wales and Victoria accounting for 62 per cent of this. In 2005/06, the gross value of Australian sheep and lamb production, including live sheep exports, was estimated at $2.1 billion. The number of lambs on hand at June 2006 dropped 6 per cent on the previous year, to 27.3 million. The fall is attributed to a 12 per cent decline in Merino lambs and a one per cent fall in first cross lambs, while second cross lambs increased by 16 per cent (MLA 2007).

Since the late 1980s, the lamb export market has become significantly more important to Australian lamb producers. In 1988, Australia exported only 16 per cent of lamb production, however 2005/06 saw Australian exports increase to 45 per cent of total lamb production (see Figure 1). Exports in 2005/06 were 147,000 tonnes, and the value of this lamb was estimated at $783.1 million (MLA 2007). Demand for Australian lamb has been stimulated by trade liberalisation in the United States, falling production in key lamb markets - particularly the United States and Europe, limited growth in exports from competitor countries like New Zealand, and rising demand in Asia as consumers look for alternative meats in the wake of disease outbreaks affecting beef and poultry (MLA 2007).

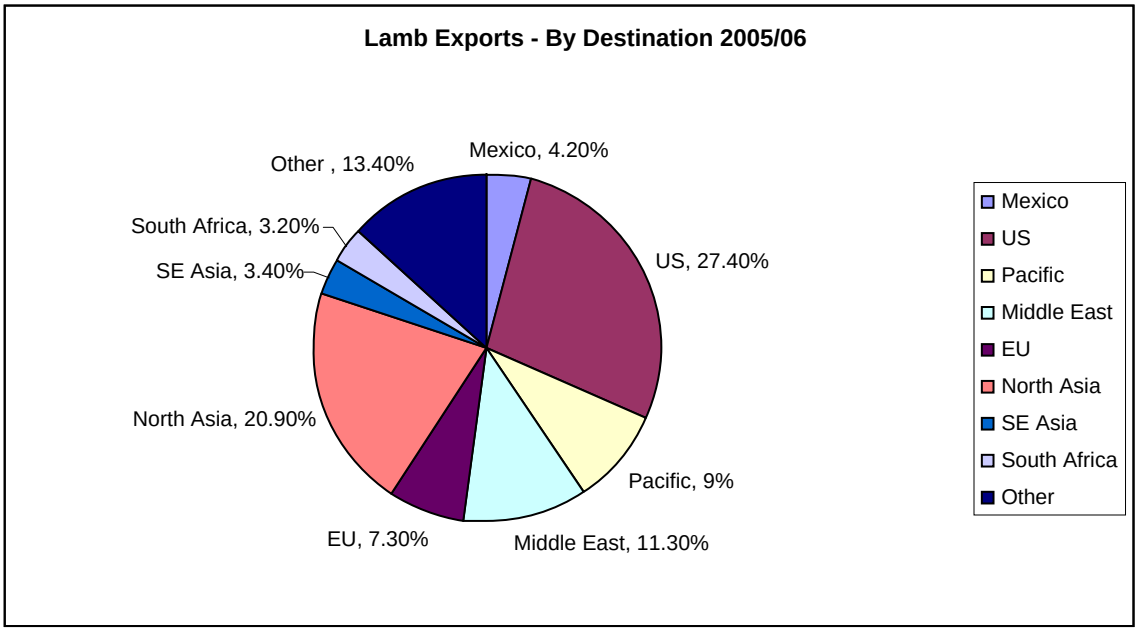
Figure 1. Australian Lamb Exports, 1990-2006 ('000 tonnes shipped weight)



Source: MLA (2007).

Figure 2 shows where Australian lamb is exported to, with the United States and North Asia representing the main export markets. Combined, they account for 48 per cent of Australia's total exports.

Figure 2. Lamb Exports by Destination, 2005/06 (%)



Source: MLA (2007).

The domestic market however remains an important sector of the lamb industry. In fact, 55 per cent of all lamb produced in Australia is sold on the domestic market. Of this, 89 per cent is sold through retail outlets, and 11 per cent is sold through the foodservice sector (MLA 2007). Despite a sharp decline in lamb demand in the 1980s and early 1990s, demand for lamb has recovered strongly since the late 1990s. Lamb demand has been particularly resilient in recent years, despite being the meat with the largest price increases since 1998. Demand in the domestic market has remained strong, with the lamb retail price 71 per cent higher than prices in 1998. According to Meat and Livestock Australia (MLA), the increase in domestic demand has largely been in response to better quality lamb, a general rise in the healthy image of red meat, and successful marketing and promotion of lamb (MLA 2007). Consumers state that they prefer leaner and possibly larger lambs (Mullen and Wohlgenant 1991).

Australia is one of the largest per capita consumers of lamb in the world. The average annual consumption per person in 2006/07 was 10.8 kilograms (MLA 2007). As a result, consumer expenditure on lamb has risen steadily over the years and is estimated to have risen $76 million (or 4.5%) in 2005/06, to $1.8 billion. Domestic utilisation of lamb in 2006/07 was around 225,000 tonnes carcass weight, which is an increase of 2.3 percent on the previous year.

Producers may sell lambs in a number of ways. The traditional method is the livestock saleyard. The saleyard system is based on averaging lambs of differing qualities in a pen on a dollar per head basis, which are then converted to c/kg estimated dressed weight by the market reporters.

Little objective feedback data is made available. The major saleyard markets are reported by the National Livestock Reporting Service (NLRS 2007), operated by MLA.

A growing sale method is Over-The-Hooks (OTH), where producers sell directly to a processor and are then paid a c/kg price negotiated on the basis of actual carcass weight and fat score[2]. This method is beneficial to producers as they are paid for what they produce. Feedback is also readily available to producers regarding the details of the lambs sold. When producing elite lambs that are both heavy and lean (22kg+, FS2/3 or leaner), this method of marketing can often be the most profitable avenue to utilise.

Forward contracts are a marketing tool generally used by exporters who have made a commitment to overseas customers to supply them throughout the year. Forward contracts are legally binding agreements that are usually written two to six months prior to the agreed delivery date. The producer is paid on a c/kg basis, which is favorable for elite lambs that are finished to the target specifications.

3. PREVIOUS RESEARCH

Mullen (1995) wished to establish the contribution of variation in fat cover and carcass weight, to variations in the price of lamb in the Homebush livestock auction and wholesale markets. There were three main motivations for his analysis.

Firstly, following Waugh's (1928) argument that the contribution of quality factors to price variation 'may prove to be fully as useful as the studies of factors causing the general level of price to change from day to day or from season to season', Mullen believed that the producer has better control of the characteristics of a lamb therefore the study would benefit the producer in a way that would help them to understand what the market demands.

Secondly, he pointed out concerns in the lamb industry that there was a divergence between the values placed by consumers on fat cover and portion size, and the implicit prices received by producers for these quality factors in live lamb auction markets. Mullen (1995) asked the question whether efficiency gains in the lamb industry can be made by the development of a weight and grade selling system, where attributes such as weight and fat cover are explicitly valued and price divergence reduced.

[2] Fat score is the fat measurement on the carcass based on the actual soft tissue depth at the GR site (the GR site being 110mm from the midline over the 12 rib). Fat score ranges from one (leanest) to five (fattest). Each fat score represents a 5mm band width.

Carcass weight refers to the 'hot standard carcass,' which is the weight of the carcass within two hours of slaughter. Carcass weight generally determines which market the product will fall into. Lambs less than 16 kilograms are referred to as light lambs. They are usually sold as complete sides of lambs at the retail level, or purchased by feeders and restockers for fattening and breeding. Light lambs are also exported to the Middle East. Trade lambs usually range from 18 to 22 kilograms. Export lambs are generally over 22 kilograms and are mainly exported to places such as the United States. Carcass weight over the years has generally increased.

The final motivation for Mullen's study was to determine if there were different prices received for different characteristics in a lamb, and if there was, would it alter the buyer's marginal implicit valuation of these characteristics.

He concluded, and confirmed widely held views, that price differentials for fat cover do exist in livestock auction and wholesale markets for lambs. Mullen reported that price premiums were paid for lambs with a fat score of four in the auction market and for a fat score of three in the wholesale market. In relation to premiums or discounts for the effect weight has on price, the results were less clearly represented, but there was a general consensus that premiums should be paid for heavier lambs because of savings in processing costs and because of attitudinal studies which suggested that consumers would prefer larger cuts of lamb (Mullen 1995). He further concluded that there was no strong evidence that in the livestock market, price differentials for fat score depended on the weight class and vice versa. Weight and fat interactions seemed to be more important in the wholesale market.

Mullen's analysis clearly confirmed that buyers discriminate between lambs that differ in fat cover and weight. Additionally, the system of fat and weight classes used in the NLRS in both the livestock and wholesale markets, does reflect differences in economic value to buyers in the markets. Mullen also noted the divergence observed in his study between price differentials for fat cover in the livestock and wholesale markets, and further that there is a divergence in the price differentials evident in these markets and perceived consumer preferences for leaner and perhaps larger lamb (Hopkins *et al*, 1985, Mullen and Wohlgenant 1991).

4. MODEL AND DATA

The current study has a similar range of motivations and related research questions. These research questions can be considered using hedonic models[3].

Hedonic Models

The basic idea of this type of analysis is to explain differences in prices received for various types of lamb (say between light ewe lambs and heavy ram lambs) by differences in their quality characteristics (such as fat cover, gender, age, etc). Two hedonic price specifications have been proposed in the literature to estimate these sorts of models. They are described by Mullen (1995). The first is the absolute price model:

(1) $P_i = \alpha P_r + \Sigma X_{ij} P_j + e_a$

where P_i is the price of a particular class or type of lamb; P_r is the price of a reference type of lamb which has a given set of quality characteristics and which is selected to best reflect

[3] These models have been widely used to assess the effects of varying quality characteristics in agricultural product markets. For example, there are a range of studies focussed on the wheat market (Ahmadi-Esfahani and Stanmore 1994a, 1994b, 1997), the cotton market (Misra and Bondurant 2000), the cattle market (Dhyvette, Schroeder, Simms and Bolze 1996; Faminow and Gum 1986; Griffith, Burgess and Davidson 1998; Schroeder, Minert, Brazie and Grunewald 1988; Walburger 2002; Williams, Rolfe and Longworth 2003) and the wine market (Oczkowski 1994, 2001; Unwin 1999), to list just a few.

underlying supply and demand factors; X_{ij} is the quantity of the characteristic j supplied by lamb type i; and P_j is the set of price differentials, away from the reference type, for a one unit change in the characteristic j. These differentials are coefficients estimated in the regression model and they can be positive (premiums, for a more-preferred characteristic) or negative (discounts, for a less-preferred chacteristic). The underlying hypothesis of the absolute price model is that the estimated premiums and discounts for quality differences are constant - the differentials are independent of price levels. An error term is added for estimation.

The second specification is the relative price model:

(2) $P_i/P_r = \beta + \Sigma X_{ij}P_j + e_r$

where the variables are as defined above. The hypothesis here is that the quality differentials are proportional to price - as prices rise the differentials expand, and as prices fall the differentials contract.

These two specifications are tested against each other using nonnested tests reviewed by Doran (1993).

Saleyard Data

A time series of sale data generated at a major saleyard and wholesale market was chosen as the measurement unit. This then leads to a number of specific data choices:

* **Selection of market**. The NLRS report on a number of saleyard centres each week. Wagga Wagga saleyard was chosen as the representative market for this study. The NLRS report that for the year ending 30 June 2007, 1,951,000 sheep were sold through the Wagga Wagga yard, making it the largest selling centre in NSW. The next largest sale centre record is Forbes, with almost 500,000 less sheep sold than Wagga Wagga. During the years 2004/05, 2005/06 and 2006/07 (MLA 2007), Wagga Wagga has remained the number one selling centre for sheep, compared to any other centre in NSW. The Wagga Wagga sale is conducted on Thursday.

Wagga Wagga has been quoted by market analysts and selling agents as being the best indicator lamb market for NSW. Lambs are drawn not only from the Riverina and Murrumbidgee areas, but also from the Upper Murray and South Eastern NSW. One of the main reasons for such a high percentage of lambs being sold in Wagga Wagga, is the ability of producers in the surrounding districts to finish lambs all year round. It is therefore widely accepted that the sales at Wagga Wagga will provide a greater variety of lambs in terms of composition and quality and, in turn, provide a better set of cross sectional data for evaluation.

* **Selection of NLRS lamb quality characteristics**. The NLRS reports contain a variety of information with the aim of providing accurate information regarding the market. Reports generally contain the following information:

- A sale summary
- Fat score

- Category weight
- Sale percentage
- Sale prefix
- Dollars per head (low, high and average)
- Estimated carcass weight (low high and average)
- Skin value (high and low)
- Sheep category (Lamb, Hogget, Young Ewes, Ewes, Wether)

From this list only two quality characteristics were chosen. These were carcass weight (4 possible classes – 16-18 kg, 18-20 kg, 20-22 kg and 22-24 kg) and fat score (3 possible classes - FS2, FS3 and FS4). The definitions of these classes are given above. Other factors known to influence price in particular markets such as age, breed, sex, grain finished and, finally, overall quality and condition, were excluded either because the variables are not reported by the NLRS or there were too few observations.

* **Selection of lamb types**. Based on the above choices, price data were collected for 12 different lamb types (4 weight classes * 3 fat score classes).

* **Selection of reference type**. One of these types has to be chosen as the reference type. Based on discussions with NLRS staff and producers and examination of sale numbers for each type, the reference type selected was 20-22 kg FS3 lambs. Thus the reference characteristics were 20-22 kg and FS3.

* **Selection of time period**. To obtain price series which covered different seasons and different market conditions, the time period selected was from 1 January 2006 to 30 June 2007. This resulted in a maximum number of 75 weekly sale observations for each of the lamb types. The maximum possible number of observations is therefore n=11*75=825.

However, analysis of the sale data supplied by NLRS revealed that the three lighter weight ranges had very few if any FS4 reports, and that the heaviest weight range had very few FS2 reports. When these four classes were omitted (leaving 7 classes), as well as weeks when no sales were held (Xmas, Easter, etc), and all zero price observations in the remaining classes, n=383.

Final Saleyard Model

For each of the 7 non-reference lamb types, the price series for that type (P_i) and the reference price series (P_r) were entered as continuous series and the series for the quality characteristics were entered as dummy variables, where the dummy took the value zero if it was identical to the reference type and one if it was different. Thus there were five dummy variables for quality characteristics (D1618, D1820, D2224, DFS2, DFS4). The data set was then organised in panel format with the possible 75 observations on each of the 7 lamb types stacked vertically. Three seasonal dummy variables were constructed and added to account for variations in pasture growth patterns, sheep breeding cycles and seasonality in demand for different types of meat, both domestically and in export markets. Where relevant, interactions between the quality characteristics were constructed and added, as were interactions between the seasonal variables and the characteristic interactions.

This resulted in final potential absolute and relative price models for the saleyard data of the general form:

(3) P_i = f (P_r, D1618, D1820, D2224, DFS2, DFS4, quarterly seasonal dummies (3), characteristic interactions (6), seasonal interactions (15)), and

(4) P_i/P_r = f (Constant, D1618, D1820, D2224, DFS2, DFS4, quarterly seasonal dummies (3), characteristic interactions (6), seasonal interactions (15)).

Wholesale Data

The NLRS also reports on the wholesale market for lamb. The NLRS utilise the services of a wholesaler from the Sydney wholesale market, who obtains data based on sales at the markets, together with information obtained from a variety of wholesalers. In the wholesale market, lambs are traded by private treaty and hence the market report is based on the cooperation of wholesalers in divulging prices that they receive for different types of lambs. The markets are based in Homebush (Western Sydney) and many of the wholesalers are based in Strathfield (Western Sydney). The information collected from these sources is provided as a range and average. The NLRS takes this data and compiles it into a wholesale report which is published weekly. These reports generally consist of information including:

- Category (Lamb, Sheep)
- Weight Range
- Fat Score
- Fat Depth
- Average price (lowest and highest prices)
- Trend

In organizing the wholesale data for analysis, the same procedures were followed as for the Wagga Wagga saleyard data. Here, there were 3 weight classes available (16-18 kg, 18-20 kg and 20+ kg) and 2 fat scores (FS2 and FS3). To align as closely as possible with the saleyard analysis, the reference price chosen was 20+kg, FS3. There were no FS2 lambs in the 20+kg weight range, and there were slightly fewer weeks when sales were reported, so in total there are n=4*67=268 observations.

Final Wholesale Model

The final potential absolute and relative price models for the wholesale data are of the general form:

(5) P_i = f (P_r, D1618, D1820, DFS2, quarterly seasonal dummies (3), characteristic interactions (2), seasonal interactions (9)), and

(6) P_i/P_r = f (Constant, D1618, D1820, DFS2, quarterly seasonal dummies (3), characteristic interactions (2), seasonal interactions (9)).

The summary statistics for the final saleyard and wholesale data sets are given in Table 1 and Table 2 respectively. As expected, the saleyard reference price series (REF) has a higher mean and less variability than the P_i series (PRICE), since the latter contains a wider range of lamb types. The ratio variable used in the relative price model therefore has a mean less than one and quite high variability. This relationship is the other way around in the wholesale data, although the means and standard deviations are very close. The means of the dummy variables generally reflect the expected proportions of those characteristics in the final data sets. There are slightly higher proportions of lighter lambs than heavier lambs in the saleyard data, and 36 per cent have fat score 2 and 13 per cent fat score 4, while in the wholesale data the proportions are exactly as expected. The seasonal dummy variables are also close to their expected proportions. The reduced data sets do not appear to be biased across any of the quality measures.

Table 1: Saleyard Data Summary Statistics

Number of Observations: 383

	Mean	Std Dev	Minimum	Maximum
PRICE	333.29869	41.12777	145.00000	413.00000
REF	339.23629	28.60573	223.50000	387.00000
PRATIO	0.98166	0.087458	0.54636	1.21924
D1618	0.34465	0.47587	0.00000	1.00000
D1820	0.31332	0.46445	0.00000	1.00000
D2224	0.28460	0.45181	0.00000	1.00000
DFS2	0.36292	0.48147	0.00000	1.00000
DFS4	0.12533	0.33152	0.00000	1.00000
SUM	0.25587	0.43692	0.00000	1.00000
AUT	0.32637	0.46950	0.00000	1.00000
WIN	0.25326	0.43545	0.00000	1.00000

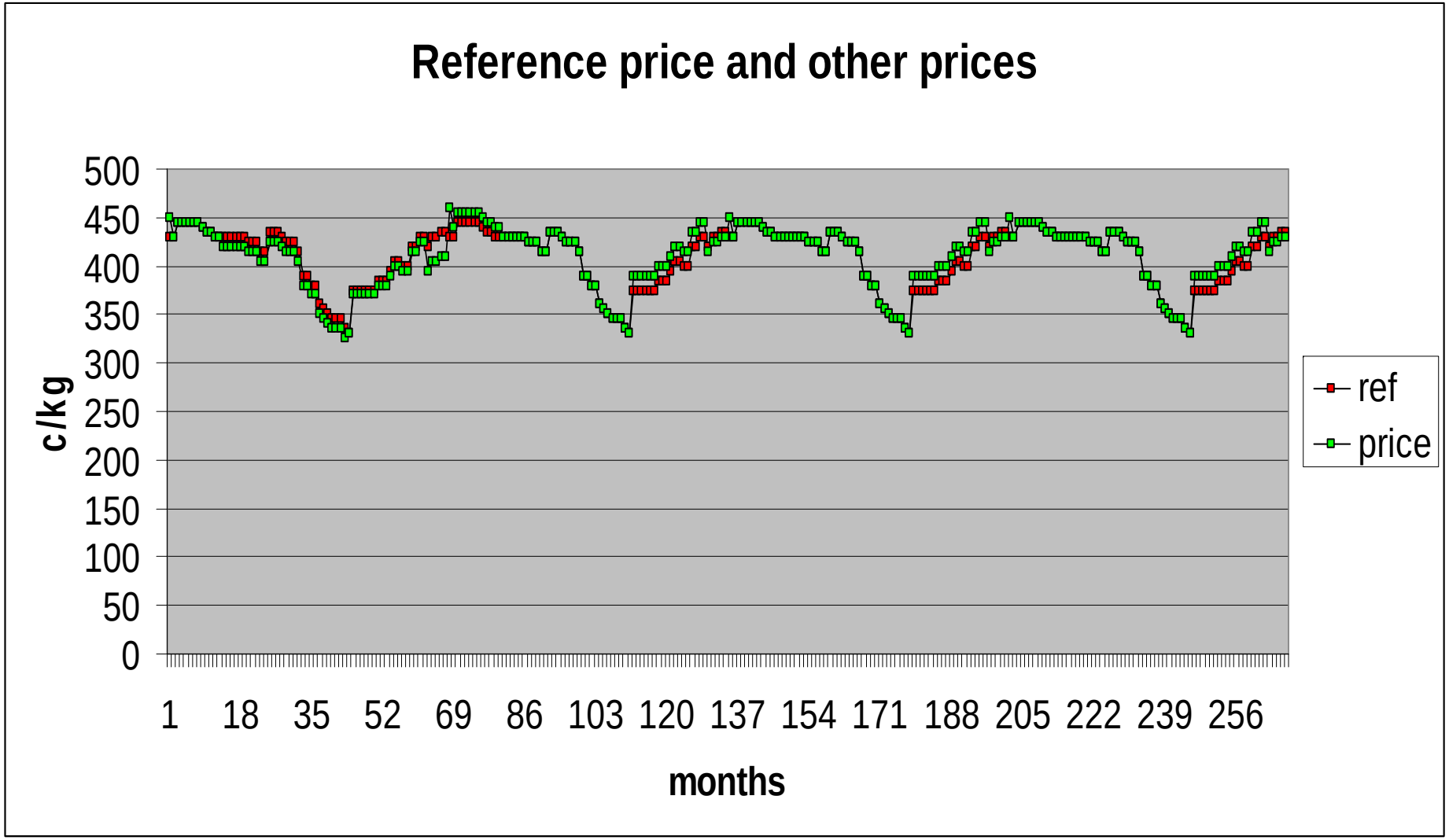
Table 2: Wholesale Data Summary Statistics

Number of Observations: 268

	Mean	Std Dev	Minimum	Maximum
PRICE	410.18657	32.01069	325.00000	460.00000
REF	408.58209	31.52558	330.00000	445.00000
PRATIO	1.00408	0.022260	0.94048	1.06977
D1618	0.50000	0.50094	0.00000	1.00000
D1820	0.50000	0.50094	0.00000	1.00000
DFS2	0.50000	0.50094	0.00000	1.00000
SUM	0.20896	0.40732	0.00000	1.00000
AUT	0.38806	0.48822	0.00000	1.00000
WIN	0.23881	0.42715	0.00000	1.00000

Figure 1 shows the close relationship between the wholesale reference price and the other wholesale prices over the four sets of 64 monthly observations.

Figure 1. Wholesale reference price and other wholesale prices



5. ESTIMATION RESULTS

Wagga Wagga Saleyard Market

In relation to the Wagga Wagga lamb auction market, the base absolute price model is presented in Table 3. It shows the relationship between the reference price, which is for a lamb of 20 to 22 kilograms with a fat score of 3, the price of all other categories of lamb, and the following dummy variables: D1618 (lamb weighing 16 to 18 kilograms); D1820 (lamb weighing 18 to 20 kilograms); D2224 (lamb weighing 22 to 24 kilograms); DFS2 (lamb with fat score 2) and DFS4 (lamb with fat score 4).

Table 3. Base Absolute Price Saleyard Model

Variable	Estimated Coefficient	Standard Error	T-statistic	P-value
REF	1.01049	.016191	62.4093	[.000]
D1618	-2.65770	5.50265	-.482985	[.629]
D1820	1.70517	5.58693	.305206	[.760]
D2224	-3.65819	5.89078	-.621002	[.535]
DFS2	-23.9800	3.01746	-7.94709	[.000]
DFS4	5.89270	4.49114	1.31207	[.190]

R-squared = .63 Adjusted R-squared = .63 Mean of dep. var. = 333.3
Durbin-Watson = 1.54 [<.000] Ramsey's RESET2 = .05 [.822]

Sixty three per cent of variation can be explained by the chosen variables. This relatively low level of explanation is to be expected given all the other possible influences on price differentials (age, breed, sex, grain finished and overall quality and condition) that are not accounted for. Positive autocorrelation exists within the estimated equation as evidenced by the Durbin-Watson statistic, however this statistic is not really that relevant to this type of sequenced data. The RESET test suggests a well specified base model.

Not all the quality characteristics were significant. The weight dummy variables are not significant and this means that if the weight class was to change from that of the reference class, there would be no significant difference from the reference price. The coefficient for the FS2 variable is significant with a t-statistic of 7.9. This suggests a significant discount of around 24 c/kg for a FS2 lamb relative to a FS3 lamb. There is also a small non-significant premium for FS4 lambs.

The model presented in Table 4 improves on the base absolute price model. Individually the seasonal variables have very significant coefficients and the F and Chi-squared tests show they should be included as a group. The difference between the reference price and the other price series is higher in summer, autumn and winter by between 17 and 27 c/kg. The other coefficients are largely unaffected by the inclusion of the seasonal variables. Again the FS2 variable is significant, showing that a discount of 24 c/kg would apply to a FS2 lamb in comparison to a FS3 lamb, but no other variables show any significant difference from zero. Overall the R squared has improved a little but there are now signs of misspecification in the model.

Table 4. Absolute Price Saleyard Model with Seasonal Effects

Variable	Estimated Coefficient	Standard Error	T-statistic	P-value
REF	.942414	.019556	48.1895	[.000]
D1618	1.72670	5.29607	.326034	[.745]
D1820	4.94240	5.37455	.919592	[.358]
D2224	.534538	5.68199	.094076	[.925]
DFS2	-23.9639	2.86660	-8.35968	[.000]
DFS4	4.67183	4.26441	1.09554	[.274]
SUM	26.6445	4.16064	6.40394	[.000]
AUT	24.7007	4.06972	6.06939	[.000]
WIN	17.4595	4.38556	3.98114	[.000]

R-squared = .68 Adjusted R-squared = .67 Mean of dep. var. = 333.3
Durbin-Watson = 1.67 [<.004] Ramsey's RESET2 = 5.29 [.022]
F(3,376) Test Statistic: 16.39, Upper tail area: .00000
CHISQ(3) Test Statistic: 47.08, Upper tail area: .00000

Several other absolute price models were run that included the interaction variables as mentioned above, but none of the groups of interaction terms proved to be significant on the basis of the calculated F and LLR tests and were therefore discarded. Two individual interaction terms were significant at the 10 per cent level, confirming that discounts for FS2 lambs were greater at lower weights.

Specification tests for functional form were also run, but these were inconclusive. The linear model as reported above was retained for ease of interpretation.

The relative price saleyard model was estimated using the same procedures as for the absolute price model. Some 28 per cent of the variation in the price ratio is explained by the estimated model and the summary statistics suggest misspecification (Table 5). This much lower level of explanatory power is to be expected given the highly variable nature of the dependent variable. The seasonal dummy variables are highly significant both individually and as a group, the FS2 dummy variable again suggests a significant discount for FS2 lambs relative to FS3 lambs (calculated to be 25 c/kg at the price means), and there are no other significant quality effects.

As with the absolute price model, several other versions of the relative price model were run to check for the inclusion of the various interaction variables, but none of the groups of interaction terms proved to be significant on the basis of the calculated F and LLR tests. As with the absolute price model, some individual interaction terms were significant, and these suggested the same patterns as in the absolute model. Finally, the specification tests for functional form were again inconclusive, so the linear model as reported was retained.

Finally the absolute and relative price models were tested against each other using J and JA tests. Two of the four test statistics rejected the relative price model and the other two rejected the absolute price model, so neither dominates. This is not seen as a problem as both models estimate approximately the same discount for FS2 lambs.

Table 5. Relative Price Saleyard Model with Seasonal Effects

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	.947198	.019980	47.4077	[.000]
D1618	-.429941E-03	.017726	-.024255	[.981]
D1820	.011980	.018073	.662837	[.508]
D2224	-.482523E-03	.019095	-.025269	[.980]
DFS2	-.074653	.922093E-02	-8.09607	[.000]
DFS4	.010626	.013537	.784973	[.433]
SUM	.079099	.012176	6.49631	[.000]
AUT	.073275	.011702	6.26153	[.000]
WIN	.049754	.012182	4.08421	[.000]

R-squared = .28 Adjusted R-squared = .26 Mean of dep. var. = .98
Durbin-Watson = 1.65 [<.002] Ramsey's RESET2 = 38.67 [.000]
F(3,377) Test Statistic: 17.10, Upper tail area: .00000
CHISQ(3) Test Statistic: 48.86, Upper tail area: .00000

Sydney Wholesale Market

The wholesale market models are similar to those of the livestock auction market, except that the number of quality variables is less as reported above. The same general procedure was followed with respect to the addition of seasonal and interaction terms, the testing of functional forms, and the comparison of the absolute and relative price models.

The absolute price wholesale model with seasonal effects included is shown in Table 6.

Table 6. Absolute Price Wholesale Model with Seasonal Effects

Variable	Estimated Coefficient	Standard Error	T-statistic	P-value
REF	1.00103	.023698	42.2419	[.000]
D1618	-1.91131	8.88032	-.215230	[.830]
D1820	3.53645	8.88032	.398234	[.691]
DFS2	-7.38806	1.12178	-6.58602	[.000]
SUM	7.29230	1.96640	3.70845	[.000]
AUT	6.77377	2.05145	3.30194	[.001]
WIN	-1.93624	2.28037	-.849087	[.397]

R-squared = .93 Adjusted R-squared = .92 Mean of dep. var. = 409.81
Durbin-Watson = 1.08 [<.000] Ramsey's RESET2 = 57.17 [.000]
F(3,264) Test Statistic: 17.35, Upper tail area: .00000
CHISQ(3) Test Statistic: 48.22, Upper tail area: .00000

Here, 93 per cent of the variation in the price variable can be explained by the chosen variables, which is a substantial improvement over the equivalent saleyard model. At the wholesale level different carcasses have different end uses depending on weight and fat score and the other

factors that influence saleyard price are less important. There is also evidence of positive autocorrelation while the RESET test suggests a poorly specified model.

The significance of the quality characteristics closely matches those of the saleyard model. The weight dummy variables are not significant and this means that if the weight class was to change from that of the reference class, there would be no significant difference from the reference price. The coefficient for the FS2 variable is significant with a high t-statistic, suggesting a significant discount of around 7 c/kg for a FS2 lamb relative to a FS3 lamb.

Individually two of the seasonal variables have very significant coefficients and the F and Chi-squared tests show they should be included as a group. The difference between the reference price and the other price series is higher in summer and autumn by around 7 c/kg. By selling in summer, the vendor will receive a price premium. It is interesting to note that unlike the livestock market, where a premium was received for lambs sold in winter over lambs sold in spring, this is not the case in the wholesale market.

Several other absolute price models were run on the wholesale data that included the interaction variables, but again none of the groups of interaction terms proved to be significant. Specification tests for functional form were also run, but these were inconclusive so the linear model was retained.

The relative price wholesale model was estimated using the same procedures as for the absolute price model.

Table 7. Relative Price Wholesale Model with Seasonal Effects

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	1.00735	.290355E-02	346.936	[.000]
D1618	-.011940	.204156E-02	-5.84863	[.000]
DFS2	-.016367	.204156E-02	-8.01671	[.000]
SUM	.023460	.336650E-02	6.96865	[.000]
AUT	.017503	.300529E-02	5.82392	[.000]
WIN	-.337392E-02	.327261E-02	-1.03096	[.304]

R-squared = .45 Adjusted R-squared = .44 Mean of dep. var. = 1.00
Durbin-Watson = .54 [<.000] Ramsey's RESET2 = 10.74 [.001]
F(3,265) Test Statistic: 38.19, Upper tail area: .00000
CHISQ(3) Test Statistic: 96.30, Upper tail area: .00000

As shown in Table 7, some 45 per cent of the variation in the price ratio is explained by the estimated model, which again is quite an improvement over the equivalent saleyard model. The summary statistics suggest misspecification. The seasonal dummy variables are highly significant both individually and as a group, the FS2 dummy variable again suggests a significant discount for FS2 lambs relative to FS3 lambs (around 7 c/kg), and in this model there is a significant discount for 16-18kg lambs relative to 20+kg lambs.

As with the absolute price model, several other versions of the relative price model were run to check for the inclusion of the various interaction variables, but none of the groups of interaction terms proved to be significant on the basis of the calculated F and LLR tests. Finally, the specification tests for functional form were again inconclusive, so the linear model was retained for ease of interpretation.

Finally the absolute and relative price models were tested against each other using J and JA tests. Three of the four test statistics rejected the relative price model or could not reject the absolute price model. This suggests that for the wholesale data, the absolute price model provides the better explanation of premiums and discounts in wholesale lamb prices due to carcass quality attributes.

6. SUMMARY AND CONCLUSION

The results of this analysis indicate that different values do apply for different quality characteristics in the Australian lamb and carcass markets. In relation to fat score, lambs that are assessed as fat score 2 are discounted relative to lambs assessed as fat score 3, by around 23 c/kg in the live lamb market and by around 7 c/kg in the carcass market. There are no significant premiums or discounts for lambs assessed as fat score 4. Premiums and discounts are now consistent across the two market levels, and this implies some improvement in the efficiency of price discovery in the lamb market since Mullen's study a decade ago. However there is still a divergence between consumers' stated preferences for leaner and perhaps larger lambs (Hopkins *et. al* 1985, Mullen and Wohlgenant 1991) and the price incentives generated in the live lamb and lamb carcass markets. Further, there is a marked difference in the discount applying to FS2 lambs at the saleyard and wholesale levels. This no doubt reflects the difference sources of risk in the two markets, where in the saleyard buyers have to estimate wool length and type as well as fat score in the live animal.

In relation to carcass weight, differences in weight in lambs and in carcasses are not associated with any significant premiums or discounts. This clearly suggests that buyers are not as concerned about the weight of the lamb as they are with having a fat score 3 or above. This finding is perhaps due to the expansion in the range of market outlets available for lamb, so that lamb carcasses that do not meet the specification of a particular market segment can be easily shifted into another market segment.

Seasonal effects in both markets proved to be quite significant. In the livestock market, premiums are paid for lambs that are sold in summer, autumn and winter compared to those sold in spring. A producer is able to receive 26 c/kg more by selling lambs in summer as opposed to spring – the highest seasonal price difference. The seasonal variables in the wholesale market also proved to be significant, although the price premiums were not as high as those in the livestock market. Again, summer received the greatest premium over spring, allowing a producer to receive 7 c/kg more. However in the wholesale market there was little difference between selling a lamb in spring and winter, which is in contrast to the results from the livestock market.

With this information, producers now have a better idea about what the domestic livestock and wholesale markets demand, and can plan to reach these targets accordingly. They can also

calculate the additional value they will receive for increases in the quality of their lambs. If a producer traditionally produces lambs with a fat score of 2 they can now work out whether it will pay to improve those lambs to fat score 3 since on average they will receive an extra 23 c/kg for fat score 3 lambs. In terms of the seasonal variables, the findings also clearly suggest that it is most beneficial for a producer to sell their lambs in the summer months compared to spring, but the producer has to assess whether the costs in so doing will be less than the extra price received.

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