WITHIN-SALE PRICE VARIATION AT CATTLE AND CARCASS AUCTIONS

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Price variability within cattle and carcass auction sales is examined through two statistical studies. A substantial element of the price variation at the cattle auction examined is found to be due to differences in the cattle-type factors—sex, carcass weight, fatness and breed, and the factors district of origin, lot size and time of sale. Several of these factors are also found to be important explanators of price variation at carcass auctions.

Introduction

A major criticism of commodity markets, such as a livestock auctions, is that prices tend to fluctuate excessively (Tomek and Robinson 1972). Certainly, this suggestion is consistent with the views of cattle producers in Australia. In a recent BAE survey on cattle selling methods, livestock producers, who sold predominantly through livestock auctions, considered that livestock auction prices were significantly more variable than prices obtained under direct selling methods, such as paddock or over-the-hooks sales.

The aim in this paper is to examine price variation within cattle and carcass auctions to gain an insight into whether there is a substantial random variation in prices, or whether the price variation perceived by producers can be accounted for, in part, by factors which influence quality variation. This is consistent with the consumer demand theory advanced by Lancaster (1966), that goods are assumed to possess multiple characteristics and the demand for a good is measured as the sum of consumers' valuations for its different characteristics.

Increased knowledge of the determinants of livestock and carcass price variation at auctions has a number of policy implications. First, if producers have a clear understanding of the factors that influence prices paid by buyers, this should strengthen their position in the trading of livestock and allow them to meet consumer demands more accurately. Second, the identification of factors important to buyers will assist the development of the recently introduced livestock market reporting services (LMRS) and the carcass classification schemes currently under trial in a number of States. Third, a clear understanding of the factors that influence the prices paid by buyers is necessary to assess the feasibility of marketing proposals such as the computerised sight-unseen trading of cattle or beef carcasses. Finally, a detailed examination of within-sale price variation has implications for pricing efficiency as it allows some assessment to be made of the general criticism that price variation at auctions is excessive.

Two studies are reported in this paper. The first involves an examina-

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tion of within-sale price variation at a cattle auction held at the Gepps Cross saleyards in South Australia. The relationship between price and the factors carcass weight, sex, age, fatness, lot size, breed, district of origin, horns and time of sale is examined. In the second study, the relationship between carcass prices at the Adelaide carcass auctions and the factors sex, age, weight, fatness and degree of bruising is examined.

Livestock Price Variation Within Cattle Auctions

To develop a model to examine livestock price variation within cattle auctions, it is necessary to draw on two areas of research: economic research on the auction system and price-quality relationships, and technical research on factors that influence carcass composition. These two areas of research are briefly reviewed below.

Economic research

In overseas research on livestock auctions, the factors weight, breed, sex and lot size have been found to have a significant influence on cattle prices (e.g. Keane and Riordan 1973; Fielder and Martinez 1974; Wittenberg 1977). In an examination of Irish cattle auctions, Keane and Riordan (1973) found no indication that the number of permanent incisors (age) had an effect on price. In an Australian study, Hogan and Todd (1979) found that lot size was the major factor explaining price differences between two centres and that it was also a significant source of price variation within auctions. Park (1979) found that live weight, fat thickness, dressing percentage and the interaction between age and dressing percentage were significant explanators of beef cattle price variations.

Another source of price variation at cattle auctions is the buyer error incurred in the subjective estimation of carcass characteristics. Research, both within Australia and overseas, has shown that buyers underestimate factors such as yield, carcass weight and skin values (Anon. 1954; Beruldsen 1970; Park 1979).

In a Queensland study, Hall (1978) found that a premium was paid at Cannon Hill on hornless cattle over horned cattle. It was noted, however, that the degree of bruising could be similar, as horned and hornless cattle were often mixed on transport or at saleyards.

Another factor that could influence price variation at cattle auctions is the time of sale of cattle within the auction. Sosnick (1963) examined bidding strategy at ordinary auctions and, from observation, he noted that buyers may hold back at the beginning of a sale to assess the going price on the basis of other buyers' bids.[1]

Technical research

The second area of research relevant to the development of a model of livestock price variation within cattle auctions concerns the technical relationships among factors such as sex, age, weight, fatness and carcass composition. The impact of these factors can be twofold as they may influence the dressing percentage from live animal to carcass and the

[1] Sosnick defines the 'going or market price' as a base price that the bidder takes as representative of prices at other markets.

yield of saleable meat from the carcass. In this study it has not been possible to identify the effect of factors on dressing percentage as a live-weight measure could not be obtained.

Characteristics affecting the value of meat retailed, such as the yield and distribution of saleable cuts, are not directly apparent to the livestock buyer and, consequently, a subjective estimate has to be made on the basis of the visual assessment of livestock characteristics, together with other relevant information made available by the livestock agent. Relevant criteria could include the weight, sex, age, fatness, breed, conformation and feeding system (Meat and Livestock Commission 1975).

The economic significance of factors such as weight, sex and fatness, has been clearly demonstrated by a number of researchers (e.g. Preston and Willis 1970). With respect to breed, Willis and Preston (1969) found that differences in the proportions of meat cuts do exist, with Charolais having a significantly greater proportion of first quality meat relative to total meat than either Brahman or Santa Gertrudis. Data on the meat content of normal carcasses of different breeds analysed by Kempster (1977) showed that most of the variation was explained by carcass weight, fat class and breed type. Adding data on carcass conformation did not significantly improve the accuracy of meat yield estimates. These findings are consistent with BAE (1976) research results in which there was little evidence to support the inclusion of a conformation variable in an operational classification scheme for beef.

The effect of animal age on the tenderness of meat has been the subject of considerable research. A good review of this research is provided by Bouton et al. (1978) who suggested that variations in animal age-tenderness relationships depend on the muscle(s) used, the age-weight range of the animals, the chilling conditions, cooking conditions and the method of assessment of tenderness. Joint relationships could also exist between age, weight and fatness, since body weight and fatness generally increase with age (Preston and Willis 1970).

The feeding system can have an impact on carcass composition and quality, largely because nutritional effects are confounded with fatness (Preston and Willis 1970). When animals slaughtered at the same age have been exposed to different levels of nutrition, their carcasses invariably differ in fatness including the extent of marbling.

The model

On the basis of the technical and economic research reviewed above, the following model was developed to examine livestock price variation at cattle auctions:

$$P = f(W, S, F, A, B, D, H, LS, T), \tag{1}$$

where P = lot price ($/head, c/kg);
W = cold carcass weight including internal fats (hot carcass weight less 2 per cent shrinkage);
S = sex, either heifer (S_0) or castrate (S_1);
F = cold carcass measurement (mm) at the 12th-13th rib interface;

A = dummy variables for the number of permanent incisors ($A_0 < 2$, $A_1 \geq 2$);
B = dummy variables for breed: Shorthorn (B_0), Hereford (B_1), Angus (B_2), other (B_3);
D = dummy variables for district of origin: Adelaide Hills (D_0), Upper South-East (D_1), Mid-North (D_2), Peninsulas (Eyre, York) (D_3), Far North (D_4);
H = dummy variable for horned (H_0), hornless (H_1) and mixed lots (H_2);
LS = number of cattle within a sale lot; and
T = time of sale in terms of pen numbers within the sale, the sale being split into four periods.

The factor 'horns' has been included in the model as a proxy for bruising. Similarly, 'district of origin' has been included as it provides some indication of the distance travelled, with consequent implications for the extent of bruising. In discussions with buyers, it was also suggested that district of origin may provide some indication of feeding regime.

The specific null hypotheses advanced for testing were as follows:

Cattle prices per head or unit (c/kg) within an auction are not significantly influenced by weight Ho_1, sex Ho_2, fatness Ho_3, age Ho_4, breed Ho_5, district of origin of cattle Ho_6, horns Ho_7, lot size Ho_8, nor by the time at which cattle are sold during a sale Ho_9.

The statistical technique used to examine within-sale price variation was analysis of covariance using regression (Johnston 1972). Sex, age, horns, time of sale, breed and district of origin were included in the model as categorical factors, while lot size, fat thickness and weight were included as covariates. The effect of horns and district of origin on bruising score was examined separately using the same statistical technique. As a regression approach was followed, individual coefficients, together with their levels of significance, were calculated for the covariate factors and the dummy categorical factors. A number of different functional forms of the regression model were considered, but no economic rationale could be found for the use of other than a linear model. However, on the basis of the technical research previously discussed, multiplicative terms for age:weight, age:fat and weight:fat were examined.

Data

The price data used in this study were collected from a Gepps Cross (Adelaide) auction sale held on 6 November 1978. A sample of seven buyers were selected for the study and it was estimated that these buyers would generally purchase approximately 40 per cent of the cattle offered at any Gepps Cross auction. The buyers represented various meat marketing activities including retailing, wholesaling and processing.

Price data were collected during the auction sale on a per-lot basis, together with information on breed, lot size, whether horned, hornless or mixed, district of origin and time of sale. The cattle were tagged and marked in the pens on an individual-lot basis during the sale to allow individual cattle to be identified at slaughter at the adjacent South

Australian Meat Corporation (SAMCOR) abattoirs. At the abattoirs, the individual carcasses were classified and the following information was collected: sex, number of permanent incisors (age), hot carcass weight, fat depth and bruising. The lot identification number was transferred from the cattle tag to a carcass tag prior to the hidepuller, to allow cattle and carcass data to be matched. An examination of the data (see Appendix A) supports the claim by livestock agents that the Monday market at Gepps Cross provides cattle most suitable to the domestic trade, that is, yearlings and lightweight steers.

The predominant cattle breeds at the auction were Shorthorn, Hereford and Angus.[2] The Angus group included some mixed lots in which the majority of cattle were Angus and some lots of Angus-Hereford cross cattle. The 'other' group covered a broad range of crossbred cattle such as dairy crosses, Hereford-Shorthorn crosses, Brahman crosses and various other mixed breeds. The districts of origin were based on information received from meat trade sources. There was general agreement on the delineation of these areas and buyers considered them important when buying livestock. The districts were considered to indicate distinct production zones reflecting different feeding regimes and transport arrangements with consequent implications for carcass quality and bruising.

Cattle were classified as heifer or castrate. As there were few bulls or cows at the sale, data on these were not recorded. The cold carcass weight was derived from the hot carcass weight less a two per cent shrinkage factor. Fat depth readings were taken on both sides of the carcass at the 12th-13th rib interface, and an average reading was recorded.

Age was assessed by dentition on the basis of the number of permanent incisors, that is, 0, 2, 4, 6 or 8. For the purposes of this study, an LMRS classification for age (fewer than 2 incisors, 2 or more incisors) was adopted as the low number of older cattle (4, 6 or 8 permanent incisors) prevented a more detailed grouping.[3]

Meischke, Ramsay and Shaw (1974) established a standard system for the recording of carcass bruises to indicate the weight of trimmed bruise tissue. In the system, each bruise is classified according to both surface area and severity in such a way that a numerical score can be allocated to each of six categories.[4] This numerical score was used in this study as a proxy for the extent of bruising.

Results and Discussion

The model developed in the previous section was specified with the dependent variable (price) on both a dollars-per-head and cents-per-

[2] The Shorthorn and Hereford breed names were used broadly to cover the Poll Shorthorn and Poll Hereford breeds as well.

[3] The first pair of permanent incisors generally erupt between 1 year 9 months and 2 years of age (Miller and Robinson 1947).

[4] There are three basic categories based on area of bruise:

'Slight': from 2-8 cm in diameter;
'Medium': from 8-16 cm in diameter; and
'Heavy': greater than 16 cm in diameter.

A two-way classification, then, relates to the depth of the bruise, namely superficial or deep.

kilogram basis.[5] Both specifications of the model were found to be significant at the 0.1 per cent level. The results of the dollars-per-head model are presented in Table 1 and the cents-per-kilogram model in Appendix Table B.1.

Through the use of the Durbin-Watson and the Kolmogorov-Smirnov tests, it was established that autocorrelation and normality problems were not significant. The Durbin-Watson test was necessary because prices were sequentially recorded over the sale. From a review of the correlation matrix, multicollinearity was not considered to be a problem as there were no correlation coefficients in excess of 0.4. No violation of the assumptions regarding homoscedasticity assumptions was apparent.

Multicollinearity problems are, however, more apparent when interaction terms are included in the models (see Appendix Table B.4). Some reservations are placed on the interpretation of these results because of the magnitude of some correlation coefficients (e.g. for the livestock auction data, age:weight−age, $r=0.9$; weight:fat−fat, $r=0.9$). All equations reported in Appendix Table B.4 were found to be significant at the 0.1 per cent level.

The explanatory power of the model is considered adequate as the factors included account for 87 per cent of the price variation within the auction sale. This result is comparable with those obtained by Wittenberg (1977).

From an examination of the results presented in Table 1, it is evident that, with the exception of age and horns, all the factors included in the model are significant. The results for each factor are now considered. To set the results in perspective, the mean cattle prices were \$136.11/head and 83c/kg. Absolute and percentage effects are reported below; the percentages are computed using the mean price as a base.

Weight

Weight was found to be a highly significant explanator of dollars-per-head price variation at the cattle auction. An increase of 1 kg carcass weight led, on average, to an increase of 47c in the per-head price (0.35 per cent).

The relationship between cents-per-kilogram prices and carcass weight, detailed in the results presented in Appendix Table B.1, shows that weight was a highly significant explanator of price variation at the cattle auction, with price per kilogram decreasing as weight increased. An increase of 1 kg in weight led, on average, to a price decrease of 0.18 c/kg or 0.22 per cent. This result is not unexpected as the majority of cattle at the sale were purchased for the domestic market. A number of buyers in the study, particularly those with supermarket outlets, stated

[5] In a comparison of the models, it will be noted that the factors are generally less significant in the cents-per-kilogram price model, with the factors of breed and lot size being insignificant. In the past, researchers have noted that potential multicollinearity problems can arise with this type of analysis (Keane and Riordan 1973; Wittenberg 1977). In this study, buyers bid on a dollars-per-head basis, and cents-per-kilogram prices therefore had to be derived (price per head/carcass weight). It is felt that this transformation of the dependent variable could account for the minor differences in significance between the models. Although in most cases the correlation coefficients between the factors included in the model are low, two exceptions are the weight-fat ($r=0.4$) and weight-age ($r=0.4$) relationships.

TABLE 1

Livestock Auction Prices, $/head

Source of variation	Sum of squares	Degrees of freedom	F	Regression coefficients
Time of sale	887.0	3	3.75†	−9.01‡ (1st Q), −3.13 (2nd Q), −3.90 (3rd Q)[a]
Breed	880.2	3	3.72†	4.71† (H/ford), 2.13 (Angus, A/X), −2.66 (others)[b]
District of origin	1617.3	4	5.13‡	−10.56‡ (Upper SE), 3.20 (Mid Nth), −3.07 (Peninsulas), −4.30 (Far Nth)[c]
Sex	3727.9	1	47.25‡	8.08‡
Age	132.2	1	1.68	2.28
Horns	75.0	2	0.48	0.45 (Hornless), −1.51 (Mixed)[d]
Lot size (covar)	447.6	1	5.67†	0.60†
Fatness (covar)	958.0	1	12.14‡	0.95‡
Weight (covar)	23580.6	1	298.88‡	0.47‡
Residual	11676.6	148		$\bar{R}^2 = 0.85$
Total	88092.6	165		$DW = 2.06$

* Significant at 10 per cent level.
† Significant at 5 per cent level.
‡ Significant at 1 per cent level.
[a] Premiums compared with fourth quarter.
[b] Premiums compared with Shorthorn Cattle.
[c] Premiums compared with Adelaide Hills.
[d] Premiums compared with horned cattle.

that the heavier carcasses of over 200 kg were less suitable for the local retail trade as they did not match consumer requirements. However, the decline in price per kilogram is not sufficient to offset the positive effects of a greater quantity of meat in heavier animals which the per-head model explicitly incorporates. A joint weight:fat relationship was also found to exist with price specified on both a per-head and a cents-per-kilogram basis (see Appendix Table B.4). The hypothesis that prices within the auction are not significantly influenced by weight is rejected on both a per-head and per-unit basis.

Fatness

Fat depth at the 12th-13th rib interface was used as the proxy for fatness. The variable was found to be highly significant and each increase of 1 mm in fat depth resulted, on average, in an increase in price of $0.95/head or 0.7 per cent (see Table 1).

In discussion with buyers it was suggested that, to match consumer requirements on the domestic market, discounts should be applied to very lean and very fat livestock. In this particular study, however, there were few cattle that could be classed as very fat as the mean fat depth was 7 mm, with 95 per cent of observations falling within the range 1-13 mm.

The positive relationship between price and fat depth is, therefore, consistent with the nature of the sample in this particular study. Hence, the hypothesis that cattle prices within the auction are not significantly influenced by fatness is rejected.

Age

The results with respect to the factor age are mixed. From the results presented in Table 1 and Appendix Table B.1, it would not appear that age is a significant explanator of price variation within the auction. However, with the dependent variable specified on a cents-per-kilogram basis, the factor age becomes highly significant after the inclusion of the age:weight interaction term (see Appendix Table B.4). The premium for the young cattle age group would appear consistent with market conditions at the domestic trade market examined. The significance of the age:weight interaction term is also consistent with technical research that illustrates the close relationship between these two factors (Preston and Willis 1970). However, no significant age:fat relationship was found.

Time of sale

Time of sale was found to have a significant influence on cattle prices within the sale. Sosnick (1963) offers a possible explanation for the discount of $9.01/head, or 6.4 per cent, on cattle sold during the first quarter of the sale compared with those sold in the last quarter (see Table 1). He suggests that if buyers' estimates of the going price are conservative, these estimates may be raised by the latest information, namely, earlier prices at the auction. If this is the case, it suggests that one of the conditions of perfect competition, namely, that all buyers and sellers should have perfect knowledge of market conditions, has not been fully met. The hypothesis that cattle prices within an auction sale are not influenced by the time at which cattle are sold is thus rejected.

Sex

Not unexpectedly, a significant premium of $8.08/head or 5.7 per cent (see Table 1) was paid on steers over heifers at the sale, this being consistent with meat trade opinion. The result could be influenced by the fact that steer carcasses yield significantly higher proportions of edible meat and bone and less excess fat than heifers (Preston and Willis 1970). The hypothesis that cattle prices within an auction are not influenced by sex is rejected.

Breed

Breed was found to be a significant explanator of within-sale price variation at the sale (see Table 1). The results illustrate that buyers paid a premium of $4.71/head or 3.5 per cent on Hereford cattle compared with Shorthorn. Although this result leads to the rejection of the hypothesis that cattle prices are not influenced by breed, it should be treated with some caution. Further research is needed with more broadly based samples covering exotic and traditional beef breeds and dairy-type cattle before any firm conclusions about buyers' preferences can be made.

Lot size

A premium of $0.60/head or 0.4 per cent (see Table 1) was paid on each unit increase in lot size. These findings are consistent with those of Hogan and Todd (1979) and the premium is of the same order of magnitude. Hogan and Todd (1979) suggested that the premium for larger lots arose as it allowed quality specifications to be more easily met. This study provides further support for this suggestion. The cattle were of a domestic trade type and the livestock agents confirmed that the main objective in lot building was to provide cattle of a similar quality and type. The hypothesis that cattle prices within an auction are not significantly influenced by lot size is thus rejected.

District of origin

District of origin was found to be a significant explanator of within-sale price variation (see Table 1). For this particular sale, it is shown that, compared with cattle from the Adelaide Hills, cattle from the Far North of South Australia sold at a significant discount of $4.30/head or 3.2 per cent and cattle drawn from the Upper South-East sold at a significant discount of $10.56/head or 7.9 per cent. The comparison with cattle from the Upper South-East must be treated with some caution as only 19 lots of cattle were drawn from this area. The majority of the cattle in the sample were drawn from the Adelaide Hills and Far North areas. The significant discount on the cattle from the Far North was consistent with buyers' comments that, even though cattle from this area might 'look' exactly like cattle from the Adelaide Hills, the quality was not of the same standard.

The results of an analysis which examined the relationship between bruising and the factors horns and district of origin, are presented in Appendix Table B.2.

These results show that the cattle from the Far North were significantly more bruised than cattle from the Adelaide Hills. This is consistent with the finding that there was a discount, at this particular sale, on cattle from the Far North. The hypothesis that cattle prices within an auction are not influenced by the district of origin of the cattle is thus rejected.

Horns

These results show that within-sale price variation was not influenced by whether cattle were sold in hornless, horned or in mixed lots (see Table 1). This is not altogether surprising in the light of the research which shows that, prior to sale, there is a high probability that hornless cattle will come into contact with horned cattle (e.g. Hall 1978; Ramsay 1976). In this particular case study, however, the results of the analysis of bruising show that hornless cattle were significantly less bruised than horned cattle (see Appendix Table B.2).

Carcass Pricing Relationships

Little economic research has been conducted on the pricing of carcasses. Objective carcass characteristics were found to explain a much greater proportion of the price variation for carcasses sold on the export

market than locally (BAE 1976). Age, weight, sex, fat and bruising accounted for 91 per cent of the variation in the prices of complete carcasses going for export, compared with 17 per cent for complete carcasses going to local trade.

A problem with the examination of carcass pricing is that price data are difficult to collect. The price data used in this study were collected from four carcass auction sales held in Adelaide during the weeks commencing 6 and 13 November 1978. The Adelaide carcass auction is the only carcass auction in South Australia and the weekly throughput of beef carcasses is approximately 45. Buyers at the auction are predominantly retail butchers. Carcasses to be sold at the carcass auction were classified at the SAMCOR abattoir in the same manner as previously described. Data on sex, age, weight, fat depth and bruising were recorded.

The model

The following model was postulated:

$$P = f(T, W, S, F, A, BR), \tag{2}$$

where T = the specific auction sale; and
BR = bruising as a numerical score.

Price was recorded on a cents-per-kilogram basis and buyers bid on this basis. After allowance for the other factors in the model, the specific null hypotheses advanced for testing, using covariate analysis, were as follows:

Carcass prices within an auction are not significantly influenced by weight Ho_1, sex Ho_2, fatness Ho_3, age Ho_4, or bruising Ho_5.

Time, sex and age were treated as categorical factors and fatness and weight as covariates. Age:weight, age:fat and weight:fat interaction terms were examined (see Appendix Table B.4).

Results and discussion

The results of the analysis of the covariance model are presented in Table 2. From these results, the hypotheses that carcass prices within an auction sale are not influenced by sex and fat are rejected. The corresponding hypotheses for weight, age and bruising are accepted. The rejection of the hypotheses for sex and fatness is consistent with the results obtained at the livestock auction. Buyers paid a premium on steers of 2.8 c/kg or 3.3 per cent. The premium is not unexpected as heifer carcasses have a lower meat yield because of the greater weight of internal (kidney/channel) fat (Everitt and Evans 1970). A premium of 0.41c/kg, or 0.5 per cent, was paid on each increase of 1 mm in fat depth.

Age was found not to influence prices recorded on a cents-per-kilogram basis, and, unlike the livestock auction, this factor did not become significant after the inclusion of an age:weight interaction term. Weight was found not to influence prices. This result differs from that of the livestock auction where price (c/kg) decreased with increasing

TABLE 2

Carcass Auction Prices, c/kg

Source of variation	Sum of squares	Degrees of freedom	F	Regression coefficient
Time (sales)	384.7	3	7.18†	
Sex	62.2	1	3.48*	2.83*
Age	39.3	1	2.20	1.89
Weight	23.9	1	1.34	−0.04
Fat	54.6	1	3.06*	0.41*
Bruising	4.2	1	0.24	−0.08
Residual	965.1	54		
Total	1584.4	62		$\bar{R}^2 = 0.30$

* Significant at 10 per cent level.
† Significant at 1 per cent level.

weight. One likely explanation is the lower weight variation for the carcass auction data (coefficient of variation = 12 per cent, compared with 22 per cent for the livestock auction). Weight is, of course, highly significant when the dependent variable (price) is transformed to a dollars-per-carcass basis (see Appendix Table B.3). As with the livestock auction, a significant weight:fat relationship was found with both specifications of the model. However, no significant joint relationships were found between either age:weight or age:fat. Bruising was another factor that was found not to influence significantly prices that buyers paid on a cents-per-kilogram basis. The factors of time, sex, age, fat, weight and bruising accounted for 39 per cent of the price variation with price specified on a cents-per-kilogram basis (see Table 2) and 86 per cent of the price variation with price specified on a dollars-per-carcass basis.

Summary and Conclusions

The model developed to examine within-sale price variation at a cattle auction accounted for 87 per cent of the variation in per-head prices. After allowance for the factors included in the model, the coefficient of variation for per-head prices reduced from 17 per cent to 7 per cent. It appears, therefore, that a substantial element of the perceived price variation at livestock auctions is due to variations in cattle type. The results do not support the criticism that price variation at auctions is excessive. Of the nine factors included in the model, seven were found to be significant. Time of sale, breed, district of origin of cattle, sex, carcass weight, fatness and lot size were found to influence significantly price variation within the auction. Mixed results were found with respect to age whilst the horns factor was not significant.

Time of sale appears to be the only significant determinant which is not linked to quality considerations. It is suggested that the discount on cattle sold during the first quarter of the sale could reflect a lack of adequate market information, with buyers holding back from bidding to assess the general level of demand. However, before any specific recommendation for improved market information could be made, it would need to be shown that the pricing efficiency gains outweighed the costs of providing such information.

In line with *a priori* expectations for the particular domestic trade-type cattle auction examined, negative (c/kg) price-weight and positive price-fat relationships were established, and buyers were found to pay a price premium on steers compared with heifers. It should be noted, however, that relationships can change easily; for example, if export buyers had entered the market strongly, then a positive (c/kg) price-weight relationship could have been established.

Although breed was found to be a significant source of price variation at the cattle auction, further research with more broadly based samples covering exotic and traditional beef breeds and dairy-type cattle is needed before any firm conclusions can be drawn. District of origin was found to be a significant explanator of price variation and it is suggested that bruising could be a causal factor underlying this relationship, as the degree of bruising was found to be related to the factors of district of origin and horns.

With respect to lot size, the results support the findings of previous research that buyers pay a premium on larger lots (Hogan and Todd 1979). This reinforces the need for livestock agents to give further consideration to interlotting to realise the price premium on larger lots.

Further research based on a sample of cattle with a wider age distribution is required before any firm conclusions can be drawn on the significance of the factor age in the pricing of cattle and carcasses.

The presence or absence of horns at the livestock auction was found not to influence price variation even though the hornless cattle were found to be significantly less bruised than the horned cattle. Although this suggests a degree of pricing inefficiency, the result was attributed to the fact that buyers are likely to be aware that horned and hornless cattle are often mixed either during transport or at auction, with consequent implications for bruising. The avoidance of this mixing would be an advantage to those producers selling hornless cattle. However, segregation of hornless cattle may be difficult to achieve under the livestock auction system.

The results of the carcass auction analysis are similar to those of the livestock auction, with a positive price-fat relationship and buyers paying a premium on steers over heifers. Weight was not a significant factor in explaining unit price variation. This is attributed to the smaller weight variation at the carcass auction sales than at the livestock auction. Age was found not to influence within-sale price variation.

The four factors that underlie the LMRS recently introduced in a number of States, and the carcass classification schemes currently under trial, are weight, fatness, sex and age. Subject to the qualifications expressed about the factor age, the results support the need for price reports for cattle sold at livestock auctions and over-the-hooks to be placed on a standardised and comparable basis.

In the development of any future sight-unseen direct selling scheme for cattle, consideration should be given to including sale information on breed and district of origin in addition to the LMRS factors of sex, age, weight and fat depth. Information on whether cattle are horned or hornless could also be of use if the marketing system allows these groups to be kept separate.

There should be some scope for producers to take advantage of the lot-size premium at cattle auctions, and in direct selling negotiations, pro-

ducers could take account of any breed or district of origin premiums. Consumer demands could also be more accurately met if the factors that influence price variation were more explicitly allowed for in price reporting and marketing systems.

APPENDIX A

Lot statistics for weight, fat depth, age and lot size are detailed in Table A.1.

The majority of cattle were yearlings suitable for the domestic market. Separate sales are held for export-type stock. The average carcass weight of 167 kg matches the type of carcass that the buyers in the study indicated was required for the domestic market. The average lot size of the sample was four, although single-head lots formed the modal group.

Although pricing is on a lot basis, it is relevant to examine the variation in carcass characteristics for individual cattle within a lot, as this will influence the ability of buyers to meet type specifications. Within-lot variation for weight, age and fat depth is shown in Table A.2.

These results are of interest because they illustrate that there is considerable variation in fat depth between cattle within lots. The coefficient of variation over all lots was 19 per cent, with 35 per cent of lots having a range of fat depth greater than 4 mm. A significant number of the lots would therefore span more than one LMRS fat score.

TABLE A.1

Cattle Lot Statistics

Item	Lots	
	No.	Proportion of total
Weight (kg dressed carcass weight)		%
101-125	18	11
126-150	43	26
151-175	45	27
176-200	35	21
201 and over	25	15
Fat (mm)		
0-2	6	4
3-5	43	26
6-8	74	44
9-11	25	15
12 and over	18	11
Sex		
Heifer	93	56
Castrate	73	44
Lot size (no.)		
1	52	31
2	39	24
3	20	12
4	10	6
5 and over	45	27
Age (no. of permanent incisors)		
0	105	63
2 or more	61	37

TABLE A.2

Within-lot Variation: Weight, Age and Fatness

Item	Lots	
	No.	Proportion of total[a]
Age range (no. of permanent incisors)		%
0	59	52
2	37	32
4	11	10
6	4	3
8	3	3
Fat range (mm)		
0	10	9
1-2	36	31
3-4	28	25
5-6	26	23
7 and over	14	12
Weight range (kg)		
0	3	3
1-10	43	38
11-20	27	24
21-30	19	17
31 and over	22	19

[a] Single animal lots are not included in this table.

APPENDIX B

TABLE B.1

Livestock Auction Prices, c/kg

Source of variation	Sum of squares	Degrees of freedom	*F*	Regression coefficient
Time of sale	485.2	3	4.59‡	
Breed	184.7	3	1.75	
District of origin	525.8	4	3.73‡	
Sex	584.0	1	16.56‡	4.25‡
Age	29.0	1	0.82	1.07
Horns	39.1	2	0.55	
Lot size (covar)	60.5	1	1.73	0.22
Fatness (covar)	169.3	1	4.80†	0.40†
Weight	3558.5	1	100.93‡	−0.18‡
Residual	5218.2	148		
Total	12268.9	165		$\bar{R}^2 = 0.53$
				$DW = 2.17$

* Significant at 10 per cent level.
† Significant at 5 per cent level.
‡ Significant at 1 per cent level.

TABLE B.2

Bruising (Livestock Auction)
(bruising scores)

Source of variation	Sum of squares	Degrees of freedom	F	Regression coefficients
District of origin	447.9	4	5.01‡	−0.25 (Upper SE), 0.64 (Mid Nth), 0.79 (Peninsulas), 3.65‡ (Far Nth)[a]
Horns	110.3	2	2.47*	−2.32* (Hornless Cattle), −2.91†(Mixed Lots)[b]
Residual	3557.1	159		
Total	4119.3	165		$\bar{R}^2 = 0.11$

[a] Bruising score compared with Adelaide Hills.
[b] Bruising score compared with horned cattle.
* Significant at 10 per cent level.
† Significant at 5 per cent level.
‡ Significant at 1 per cent level.

TABLE B.3

Carcass Auction, $/carcass

Source of variation	Sum of squares	Degrees of freedom	F	Regression coefficient
Time (sales)	1016.8	3	40.28†	
Sex	116.6	1	2.59	3.88
Age	92.8	1	2.06	2.90
Weight	8348.3	1	185.18†	0.76†
Fat	112.7	1	2.50	0.58
Bruising	20.9	1	0.46	−0.19
Residual	2434.5	54		
Total	16961.4	62		$\bar{R}^2 = 0.84$

† Significant at 1 per cent level.

TABLE B.4

Regression with Interactions: Age:Weight, Age:Fat, Weight:Fat Livestock Auction[a]

	Const	T_1	F	B_1	D_2	S_1	H_1	B_3	A_1	LS	T_3
Price ($/head)	32.27 (9.34) ‡	−9.52 (2.79) ‡	4.35 (1.10) ‡	5.14 (1.96) ‡	4.09 (2.95)	9.57 (1.61) ‡	0.31 (2.42)	−2.39 (2.07)	−11.46 (8.43)	0.56 (0.25) †	−3.46 (2.34)
Price (c/kg)	105.11 (6.03) ‡	−6.57 (0.80) ‡	2.82 (0.71) ‡	2.32 (1.26) *	2.92 (1.91)	5.62 (1.04) ‡	0.35 (1.57)	−1.28 (1.33)	−20.13 (5.45) ‡	0.21 (0.16)	−3.10 (1.51) †
	D_1	B_2	D_4	W	D_3	T_2	H_2	A_1F	A_1W	WF	
Price ($/head)	−10.23 (2.88) ‡	2.05 (2.21)	−4.07 (2.06) *	0.56 (0.06) ‡	−0.78 (2.76)	−2.29 (2.39)	−0.86 (2.94)	0.40 (0.63)	0.60 (0.05)	−0.02 (0.007) ‡	$\bar{R}^2 = 0.86$ $DW = 2.05$
Price (c/kg)	−6.33 (1.86) ‡	0.90 (1.43)	−2.15 (1.33)	−0.16 (0.04) ‡	0.75 (1.78)	−1.33 (1.54)	−0.59 (1.90)	0.19 (0.41)	0.11 (0.03) ‡	−0.01 (0.004) ‡	$\bar{R}^2 = 0.58$ $DW = 2.16$

Carcass Auction[b]

	Const	CS_3	CS_2	CS_1	A_1	S_1	F	WF	A_1W	W	BR	A_1F	
Price ($/body)	−30.14 (21.49)	3.95 (2.60)	−7.61 (2.47) ‡	−5.93 (2.62) †	−20.78 (17.83)	5.19 (2.50) †	7.85 (3.32) †	−0.05 (0.02) †	−0.10 (0.11)	1.00 (0.14) ‡	−0.09 (0.28)	0.32 (0.86)	$\bar{R}^2 = 0.84$
Price (c/kg)	67.87 (13.68) ‡	2.24 (1.66)	−4.95 (1.57) ‡	−3.60 (1.67) †	−14.86 (11.34)	3.55 (1.59) †	4.25 (2.11) †	−0.02 (0.01) *	0.08 (0.07)	0.83 (0.09)	−0.03 (0.18)	0.07 (0.55)	$\bar{R}^2 = 0.32$

* Significant at 10 per cent level.
† Significant at 5 per cent level.
‡ Significant at 1 per cent level.
[a] See pages 32-3 for explanation of notation.
[b] Notation as for livestock auction except separate auctions are represented by dummy variables CS_1, CS_2, CS_3, and $CS_4 = 0$.

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