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EMPIRICAL TESTS OF SPATIAL AND STRUCTURAL EFFECTS ON CATTLE AUCTION PRICES

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Two investigations are reported. The first is a comparison of average prices for two cattle types within pairs of some major auction centres in Australia. Significant price differences existed in three of the four cases studied. The second is a study of the main determinants of price differences between auction selling centres through a case study of a large and small auction centre. The major factor explaining the price differences between the two auction centres was lot size. This factor also influenced price variation within auctions. The number of buyers purchasing cattle did not affect price levels.

Introduction

The livestock auction is the principal selling method for cattle for all States except the Northern Territory (BAE 1978, 1979). The livestock saleyard provides the physical location for buyers and sellers to determine prices in what is generally regarded as a competitive environment, with open access to both export and domestic demand. It allows for the quick clearance of a product which is difficult to standardise and costly to store.

The aim in this paper is to examine some aspects of the efficiency of pricing in the livestock auction system, using readily available data. Traditionally, efficiency is considered against the conditions of perfect competition, namely, homogeneity of the product, smallness of each buyer or seller relative to the market, absence of artificial restraints, mobility of goods, services and resources and the adequate availability of information (Leftwich 1970).

Two studies are reported in this paper. The first is concerned with a comparison of reported average cattle prices within pairs of major auction centres in Victoria and New South Wales to determine whether unexplained price differences and potential imperfections occur. The second is an examination, through the use of a case study, of whether lot size, number buyers and saleyard size have an impact on price formation within centres and price differences between centres. The rationale for the examination of these factors is discussed in the second part of this paper.

Whilst there is a considerable body of literature (Anon. 1972; Anon. 1973; Cozens 1973; BAE 1974; Cameron 1976; Prices Justification Tribunal 1978) on the auction system covering description of the physical facilities, the operation of auction sales and the role of the

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auction market as a market institution, there has been little research conducted on the efficiency of the auction system in terms of operational and pricing aspects. From time to time, criticisms are levelled at the auction system concerning issues such as buyer collusion and excessive price variability. However, there is little objective research evidence to support such criticisms.

McPherson (1956) and Stout and Feltner (1962) in the U.S.A. and Beruldsen (1970) in Australia have examined efficiency aspects of livestock pricing between selling centres. The principal finding of Stout and Feltner was the tentative conclusion that, for slaughter hogs, there was no price advantage in selling at a central terminal market as opposed to a country centre. McPherson tentatively concluded that large cattle auctions provided a more accurate price discovery mechanism than small auctions, as price variability was found to be higher at the small auction centres. In a comparison of prices at New South Wales country lamb selling centres and at Homebush, Beruldsen found that, in 11 out of 13 cases, country auction prices were lower, after adjustment for transport costs, than the comparable metropolitan prices. It was tentatively suggested that the price premium in favour of the metropolitan centre arose because of 'relative weak competition and/or buyer collusion in bidding' at the country auctions (p. 94).

An Analysis of Price Differences Between Selling Centres

If price formation is efficient, then, according to conventional theory, prices at different selling centres should be identical after allowance has been made for time, form and place (Williams and Stout 1964; Kohls and Downey 1972). To examine whether this condition holds, a number of centres were selected in Victoria and New South Wales and pairs of centres were examined.

Difficulty was encountered in selecting pairs of centres as, prior to the introduction of improved livestock market price reporting services (LMRS), there was no standard basis for published price reports. For a number of country centres a price comparison was not possible as only a price range or top price for broad cattle types was reported. Thus the centres selected were those for which prices are reported on an LMRS basis.[1]

In selecting pairs of centres it was necessary to determine the direction of cattle flow and the transfer costs between the centres. As the study involved a comparison between prices at a country saleyard (Wagga Wagga) and two metropolitan saleyards, Homebush (Sydney) and Newmarket (Melbourne), the direction of cattle flow and consequent transfer costs could readily be determined. The major cattle flow was from Wagga Wagga to Melbourne.

The hypothesis considered in the comparison of average daily saleyard prices in the pairs of centres under study was as follows:

$H0_1$: At any pair of auction centres, average cattle saleyard prices are equal after allowance has been made for time, cattle type and the transport costs between centres.

[1] Price quotes were obtained from various issues of:—
New South Wales Department of Agriculture, *Weekly Marketing Notes*, Division of Marketing and Economics, 1977 and 1978; Victorian Department of Agriculture, *Weekly Livestock Report*, Economic Branch, 1977 and 1978.

This was tested against the alternative hypothesis that cattle prices were not equal.

Methodology

Average saleyard cattle prices were collected for a period of 35 weeks commencing in November 1977. Where possible, saleyard prices for the pair of centres being examined were collected for the same day. If this was not possible, the time difference between sales was kept to the minimum feasible.

For certain of the pairs of centres included in the study, the livestock sales are held on different sale days. It was thought that this could influence the differences in average prices between selling centres. A test of significance for differences in average prices between sale days within a week was conducted, using analysis of variance for two cattle types sold at the Monday and Thursday sales at Homebush. The hypothesis that there was no significant difference in average prices for the cattle types examined at the Monday and Thursday sales (within a week in a given auction centre) was accepted at the 1 per cent level. Therefore, although for certain of the comparisons the sales were held on different sale days, it was considered that this source of price variation was small and could be ignored in the analyses.

Two LMRS cattle types were compared, one domestic and the other export. The domestic type chosen was a category of young cattle, with an estimated dressed weight of over 160 kg and fat condition score 4. The export type chosen was a category of light cow, with an estimated dressed weight of up to 250 kg and fat condition score 3. Both cattle types chosen are traded in large numbers at the centres selected.

The transfer cost between centres was determined by calculating the road transport costs for the cattle types under examination. The transport costs were obtained from a large freight firm operating at the centres examined.

The Model

The general model was as follows:

$$P_{ct} - P_{mt} = d_t,$$

where

P_{ct} = price of cattle type at country centre in week t,
P_{mt} = price of corresponding cattle type at metropolitan centre in week t, less transport costs between the centres in week t,
d_t = difference between country and metropolitan prices not attributable to transport costs in week t.

To examine whether the average prices are equal at any pair of auction centres after adjustment for transport costs, the specific statistical hypothesis required to hold is:

$H0_1 : d_t = 0$
$HA_1 : d_t \neq 0.$

Results and Discussion

The Student's t statistic for paired observations was used to test $H0_1$. The results for the two cattle types examined are presented in Table 1. In three of the four comparisons the null hypothesis was

TABLE 1

Results for Large Centre Comparisons

Centre comparison	Cattle type	d_t[a] c/kg	Std dev.	t
Wagga-Homebush	young cattle	3.22	1.12	2.88***
Wagga-Newmarket	young cattle	—1.75	0.91	—1.92*
Wagga-Homebush	cows	3.49	0.67	5.29***
Wagga-Newmarket	cows	3.59	0.93	3.86***

[a] Premium with respect to country centre after adjustment for transport cost.
*** Significant at the 1 per cent level. * Significant at the 10 per cent level.

rejected at the 1 per cent level. In the comparison of average cattle prices between Wagga/Newmarket and Wagga/Homebush there is a significant price premium in favour of Wagga Wagga in three of the four cases. However, no conclusion may be drawn as to whether there is a price premium in favour of either metropolitan or country auction centres as Wagga Wagga is the only country centre that is compared with metropolitan centres.

A number of factors could have contributed to the significant price differences in reported prices. These fall into two categories. Firstly, the allowance for time, form and place may not have been adequate and, secondly, price differences between selling centres could exist if any competitive distortions influence pricing. With respect to the former, if factors that are not accounted for under the LMRS descriptions, such as lot size and breed influence price, then differences in reported prices could exist if the distributions of these factors differed between centres. In addition, the accuracy of the LMRS prices will influence the price relationship between the pairs of centres included in the study. The level of accuracy will also be influenced by the sample size underlying the price reports as well as by errors that arise in subjectively estimating the cattle type, age, weight and condition factors. With respect to the second category, the degree of buyer competition, the possible existence of buyer collusion and imperfect information at the producer level have been suggested as being factors that influence the price levels at different selling centres (Beruldsen 1970; Anon. 1972; Cozens 1973; Australian National Cattlemen's Council 1978; Cattlemen's Union of Australia 1978).

In the next section of this paper the rationale for certain factors within these categories influencing price differences between selling centres is reviewed and the relationship between these factors and price is examined through the use of a case study.

Analysis of the Effect of Lot Size, Number of Buyers and Size of Auction Centre on Prices Paid for Two Cattle Types

As previously discussed, price differences between selling centres could be the result of an inadequate allowance for time, form and place. To allow for a further dimension of product form, lot size was included in the model to examine price differences between selling centres. At livestock auctions, cattle buyers are commonly required to

meet defined type specifications with respect to factors such as carcass weight and condition. These specifications are met primarily on the basis of a subjective visual assessment. It is consequently suggested that a buyer can more accurately match a few large lots to quality specifications rather than numerous small lots. In overseas research, Chambliss and Bell (1974) found that interlotting of feeder cattle led to increased efficiency, higher prices and favourable attitudes on the part of both sellers and buyers.

One of the conditions for perfect competition, namely the need for a large number of buyers and sellers none of whom should be large enough to influence the price of what he is buying or selling, provides a useful benchmark for examining buyer competition. In a theoretical examination of bidding strategy at ordinary auctions, Sosnick (1963) found that, with a model based on seven bidders, it would be extremely difficult for a person to bid monopsonistically at auctions. In a simulated study of an auction market, Whan and Richardson (1969) found that an auction held with less than four bidders did not provide enough competition to force buyers to pay their predetermined valuation.

In the case of wool auctions, Gruen (1960) came to the general conclusion that it was unlikely that buyers' pies have had any major effect on the competitive determination of prices at Australian wool auctions. However, no published research within Australia has established a relationship between price levels and the extent of collusion in livestock markets.

Against this background, the relationship between the actual number of buyers purchasing a defined cattle type at an auction and price is examined in this section. A more effective measure of competition would be the number of active bidders, but it is very difficult to obtain such data. In addition, a more rigorous examination of the nature of competition would require information about other factors such as the number and size of firms represented by buyers and the nature of the supply function. Piggott (1970) concluded that, even in the absence of market buyer concentration, there may be an incentive towards collusive buying if supply is highly inelastic.

Centre size is another factor that could be important, as McPherson (1956) found that price variability was higher at small auction centres. It has also been suggested that price variation at auction sales depends on the number of effective buyers (Cozens 1973). Centre size could thus be significant if buyer competition is lower at the smaller centres or if monopsonistic practices are more common at such centres. However, in a competitive market, centre size should not be significant after adequate allowance has been made for time, form and place.

To examine the effect of these factors on pricing, two New South Wales auction centres (one large, one small) less than 50 km apart were selected.[2] The large centre had a throughput in excess of 1500 cattle a week whilst the other centre had a throughput of less than 500 head a fortnight.

The hypotheses detailed below were formulated to examine the effect of lot size, number of buyers and size of centre on cattle prices after taking into account time of sale, cattle type and transport costs.

[2] The large centre selected was not one of those examined in the first part of this study.

$H0_2$: There is no significant difference in the level of cattle prices at the small and large centres, after allowance for time, weight, transport costs and lot size.

$H0_3$: Average cattle prices within a centre are not influenced by lot size, after allowance for time, weight, and number of buyers.

$H0_4$: Average cattle prices within a centre are not influenced by the number of buyers attending an auction sale, after allowance for time, weight and lot size.

$H0_5$: There is no difference in the level of auction sale price variability between the small and large selling centres.

Methodology

An initial difficulty encountered with the case study was to find an appropriate basis for a pricing comparison between the small and large centres. As both centres chosen for the study provide liveweight selling facilities, a weight-by-sex basis was selected for the comparison. Two steer categories and two cow categories were selected to represent domestic and export type cattle, respectively. Although it was not possible directly to include factors such as condition and age, it was assumed that, because the centres were in close proximity, the variability in these two factors and other relevant factors would be similar for the two centres.

The weight ranges chosen for the cow and steer categories were as follows (these are approximately equal to 50 kg dressed weight intervals):

Steers:	Category 1	280-360 kg l.w.
	Category 2	361-450 kg l.w.
Cows:	Category 1	361-450 kg l.w.
	Category 2	451-550 kg l.w.

Data for individual transactions were collected from the saleyard books of a sample of the livestock agents operating at the two selling centres for the period of November 1977 to June 1978. Data were collected with respect to weight, sex, lot size, price and number of buyers who purchased the above cattle types. Paired sale weeks were recorded and, since there was only an average of one sale a fortnight at the small centre, the number of sales recorded ranged from 8 to 16, depending on cattle type and number sold. The total number of price observations ranged from 46 to 334.

The statistical technique used to examine the prices paid for comparable types at the two centres was an analysis of covariance using the regression approach (Johnston 1972). The SPSS package was used for analysis of the data. A feature of SPSS is the reporting of regression coefficients for the covariate and categorical factors. These coefficients are reported as differences and premiums in Tables 2 to 4 whilst the analyses of covariance results are reported in the Appendix. The effect of price variations between sales was allowed for by including a time variable with discrete weekly categories as a factor in the analysis of covariance. However, an additional problem arose because the sales at the two centres were not held on the same day, with the sale at the smaller centre being held later in the week. An OLS regression model was used to test for the existence of time trends at the two centres over

the period of the study. It was found that a slight but significant time trend did exist between prices at the two centres for the four cattle types, with prices rising over the study period. Since the large centre's sale day was earlier in the week than the small centre's sale day, if any price premium was found in favour of the large centre (as hypothesised in $H0_2$), it would tend to be slightly underestimated.

The influence of cattle type was controlled to some extent by selecting particular steer and cow categories. A further allowance for weight was made by including this factor as a covariate. Freight costs were obtained from a transport firm operating at the two centres and allowed for in the same manner as in the previous analysis. Prior to testing the hypotheses, the following model was used to determine whether apparent price differences existed between the two centres:

Price = f [time (weeks), weight, centre size].

The existence of price differences is of importance as they are likely to be apparent to producers and livestock buyers under existing market price reports. Such differences may be real if there are competitive distortions in pricing or only apparent if a factor such as lot size is shown to be significant.

The model for $H0_2$ was as follows:

Price = f [time (weeks), weight, lot size, centre size].

A full model including the factor number of buyers was not used because of multicollinearity problems. The number of buyers attending a sale was found to be highly correlated with the size of the centre (r = 0.75 to 0.87 depending on cattle type). A single model was not used to test $H0_2$, $H0_3$ and $H0_4$ as these hypotheses relate to both between centre and within centre aspects of pricing. For example, centre size is not relevant when the relationship between lot size and price is examined within auction sales at either the small or large centre.

Hypotheses $H0_3$ and $H0_4$ were tested with the following model, estimated separately for each centre:

Price = f [time (weeks), weight, lot size, number of buyers].

In determining the models, a number of interaction terms were considered such as a lot size/centre size interaction. However, no consistent relationship between the interaction terms and price was found and thus interactions were excluded from the final models. Lot size, weight and number of buyers were treated as covariates and time and centre size were treated as categorical factors.

With respect to $H0_5$, an F statistic was used to test for differences in the level of price variability between the two centres.

Results and Discussion

Apparent price differences between the two centres

An analysis of covariance model was used to determine whether the apparent level of prices varied between the two centres. The results are reported in Appendix Table A.1 for each cattle type examined. The price differences are presented in Table 2.

These results show that, for three of the four cattle types examined, there were apparent price differences in favour of the large centre, after allowance for the influences of freight, weight and time. The significant price differences, in favour of the large centre, ranged from \$2.82/head (or 3.6 per cent of the average price) for cow category 1

TABLE 2

Apparent Price Differences between the Two Centres

Cattle type	Price differences between centres (in favour of large centre)		Average price[a]
	c/kg	$/head[b]	$
Steer category 1	3.35***	10.72	78.25
Steer category 2	1.40***	5.68	113.60
Cow category 1	0.70**	2.82	78.33
Cow category 2	0.17	0.86	107.50

*** Significant at the 1 per cent level. ** Significant at the 5 per cent level. * Significant at the 10 per cent level using the *F* statistic.

[a] The average price is the grand average for the two centres combined for the median weight of each type (see footnote 3).

[b] Per head premiums are calculated from the c/kg premium and based on the median weight for each cattle type (see footnote 3).

to $10.72/head (or 13.7 per cent of the average price) for steer category 1.[3] The price difference for cow category 2 was not significant.

An expanded model is considered in the next section to examine the causal factors underlying the price differences in favour of the large centre.

Centre size

If the level of competition was markedly different at the small and large centres, as has been suggested, it could be expected that some centre effect would still exist after the factors of weight, time, lot size and transport costs have been allowed for. The results of an analysis of covariance model used to determine the relationship between price and time, weight, lot size and centre size are detailed in Appendix Table A.2 and the centre premiums are presented in Table 3.

After the inclusion of lot size in the model, a significant centre effect existed for only one out of four types as opposed to three out of four previously (see Table 2). For this type, namely steer category 1, the price premium in favour of the large centre was 2.37c/kg or $7.59/head.

A price premium for steer category 1 could exist if the average quality of the cattle, in terms of factors such as fat condition and age, were consistently better at the large centre. This is conceivable as the large centre is likely to draw on a wider area than the small centre. It is thus consistent that there is no large centre premium for the cow categories as it is generally accepted that the prices of export type stock are less affected by quality factors, with weight being the most important consideration.

[3] Per head premiums are calculated on the basis of the median weight group for each cattle type.

Cattle type	*Median weight* kg (l.w.)
Steer category 1	320
Steer category 2	406
Cow category 1	405
Cow category 2	500

TABLE 3

Centre Premium after Inclusion of the Lot Size Factor

Cattle type	Centre premium (in favour of large centre)	
	c/kg	$/head
Steer category 1	2.37**	7.59
Steer category 2	0.87	3.51
Cow category 1	0.22	0.89
Cow category 2	—0.06	—0.29

In conclusion, hypothesis $H0_2$, that there is no difference in the level of cattle prices at small and large selling centres, after allowance for the transport cost differential, weight, time and lot size, is accepted. This implies that there is no difference in the overall level of competition at the two centres examined in this case study.

Because of the difference in average lot size between the large selling centre (8.45 head per lot) and the small selling centre (3.29 head per lot), average lot size appears to be a major causal factor underlying the difference in prices at the two centres.

Lot size

The relationship between lot size and price was examined for the individual centres. The results are reported in Appendix Table A.3 and the lot size premiums are presented in Table 4 below. From these results, lot size is shown to be an important source of price variation within the large and small auction centres. For the individual centres, lot size is shown to be significant in five out of eight examples. Depending on cattle type, the price premium per unit increase in lot size ranged from $0.45/head to $0.61/head at the large centre and was $1.06/head for one cattle type at the small centre.

TABLE 4

Price Premium per Unit Increase in Lot Size

Cattle type	Large centre		Small centre	
	c/kg	$/head	c/kg	$/head
Steer category 1	0.19***	0.61	0.33**	1.06
Steer category 2	0.13**	0.53	0.20*	0.81
Cow category 1	0.15***	0.61	0.03	0.12
Cow category 2	0.09***	0.45	0.10	0.50

In conclusion, the hypothesis that average cattle prices are not influenced by cattle lot size is rejected.

Number of buyers

As previously stated, it has been suggested that buyer competition is related to the number of effective buyers and size of centre (Cozens

1973). The results presented in Table 5 show that the average number of buyers for the four categories sampled ranged from twelve at the large centre to six at the small centre. In all cases the number of buyers for individual categories was significantly lower at the smaller centre.[4]

TABLE 5

Number of Buyers over Sample Period

Cattle type	Large centre		Small centre	
	Range	Average	Range	Average
Steer category 1	3-14	9	2-9	5
Steer category 2	6-12	8	3-6	4
Cow category 1	3-12	8	2-7	4
Cow category 2	4-8	6	1-4	3
All categories		12		6

Appendix Table A.3 shows that no relationship was found between price and number of buyers at either the large or small centre. In conclusion, the hypothesis HO_4, that average cattle prices are not influenced by the number of buyers attending an auction sale, is accepted for the two centres included in this case study.

Price variability

The final hypothesis was concerned with whether there was a difference in the level of auction sale price variability at the small and large selling centres, after allowances for the transport cost differential. The results of the comparison of the variances for the four cattle types at the two centres are presented in Table 6. The hypothesis that the small centre price variance is less than or equal to the large centre price variance is tested against the alternative hypothesis that the price variance at the small centre (sc) is greater than the price variance at the large centre (lc).

$$HO_5 : \sigma^2_{sc} \leqslant \sigma^2_{lc},$$
$$HA_5 : \sigma^2_{sc} > \sigma^2_{lc}.$$

TABLE 6

Comparison of Price Variability between Centres

Cattle type	Coefficient of variation for large centre	small centre	F
	%	%	
Steer category 1	23.6	28.7	1.189
Steer category 2	14.8	16.0	1.009
Cow category 1	20.1	27.0	1.692***
Cow category 2	12.5	18.4	2.303***

[4] Paired t test at the 1 per cent level of significance.

In all cases, the price variance at the small centre was greater than at the large centre. However, the difference was significant for only the two cow categories. These results provide some support for the suggestion that prices at a small centre tend to be more variable than prices at a large centre.

Summary and Conclusions

In the first part of the study, average cattle prices were compared for pairs of major auction centres in Victoria and New South Wales. For three out of the four comparisons the hypothesis, that average cattle prices are equal after adjustment for transfer costs, was rejected.

Factors not accounted for under the LMRS system, such as lot size, the degree of buyer competition and the accuracy of reported prices, were suggested as factors that could influence the relationship between reported prices in the pairs of centres examined. In the light of the results presented in the second section of the study, it is considered that lot size can be the major factor accounting for differences between selling centres.

The main policy implication of the first section of the study is that the advent of LMRS price reports has facilitated price comparisons between alternative selling centres. At present, State Departments of Agriculture provide price reports for only some of the major auction selling centres. It is considered that it would be advantageous for this service to be extended to other selling centres. However, the costs are likely to prohibit governments providing the service at all centres. Thus, consideration should be given by governments to encouraging livestock agents at the smaller centres to provide price reports on the same basis as LMRS reports. If necessary, the accuracy of these reports could be monitored from time to time.

In the second section of the paper the relationship between price and the factors of lot size and number of buyers has been examined. The study was conducted for two auction centres in New South Wales (one large and one small) less than 50 km apart.

Lot size was found to be the major factor influencing the price difference between centres as the average lot size was lower at the small centre. For the individual centres, lot size was shown to be significant in five out of eight cases. Depending on cattle type, the price premium ranged from \$0.45/head to \$0.61/head at the large centre and was \$1.06/head for one cattle type at the small centre. An example of this effect is that, if a producer of steer category 1 who sold at the small centre had lot size increased from the average of the small centre (3.29) to the average of the large centre (8.45), he would gain a premium of \$5.47/head.

It is considered that premiums were paid for the larger lots because they allowed quality specifications to be more easily met. Additionally, the purchase of a few large lots rather than a larger number of small lots may simplify the buying process.

It has been suggested that prices for a particular cattle type would be lower at small centres compared with large centres because of the lower level of competition. The findings of this case study do not support this. With the inclusion of lot size, no consistent premium was found in favour of the large centre. Additionally, no relationship was

found to exist between price and number of buyers within the individual centres.

The consistent premium for lot size indicates the need for livestock agents to give further consideration to increased interlotting to realise the price premium for larger lots. The scope for interlotting is likely to be greater at large centres and this has implications for the continuing rationalisation of the number of saleyards.

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APPENDIX

TABLE A.1

Apparent Price Differences between Centres

Cattle type	Source of variation	Sum of squares	Degrees of freedom	F
Steer category no. 1	Main effects	13915.7	17	34.47***
	Time (weeks)	12087.4	15	33.93***
	Centre	1042.3	1	43.89***
	Weight (covar)	874.0	1	36.80***
	Residual	10116.7	426	
	Total	24032.3	443	$R^2 = 0.58$
Steer category no. 2	Main effects	9831.2	12	62.45***
	Time (weeks)	9478.6	10	72.26***
	Centre	96.2	1	7.34***
	Weight (covar)	129.7	1	9.89***
	Residual	3174.6	242	
	Total	13005.8	254	$R^2 = 0.76$
Cow category no. 1	Main effects	10689.5	18	58.29***
	Time (weeks)	10209.4	16	62.63***
	Centre	50.2	1	4.93**
	Weight (covar)	955.0	1	93.73***
	Residual	4839.7	475	
	Total	15529.2	493	$R^2 = 0.69$
Cow category no. 2	Main effects	2851.8	10	92.90***
	Time (weeks)	2837.3	8	115.53***
	Centre	1.0	1	0.32
	Weight (covar)	4.8	1	1.55
	Residual	497.3	162	
	Total	3349.1	172	$R^2 = 0.85$

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

TABLE A.2

The Effect of Centre Size on Cattle Prices after the Inclusion of Lot Size Factor

Cattle type	Source of variation	Sum of squares	Degrees of freedom	F
Steer category no. 1	Main effects	14250.2	18	34.40***
	Time (weeks)	11812.9	15	34.23***
	Centre	420.1	1	18.25***
	Weight (covar)	676.2	1	29.38***
	Lot size (covar)	334.5	1	14.54***
	Residual	9782.1	425	
	Total	24032.3	443	$R^2 = 0.59$
Steer category no. 2	Main effects	9907.2	13	59.27***
	Time (weeks)	9552.2	10	74.29***
	Centre	27.1	1	2.11
	Weight (covar)	110.5	1	8.60***
	Lot size (covar)	76.0	1	5.91**
	Residual	3098.6	241	
	Total	13005.8	254	$R^2 = 0.76$
Cow category no. 1	Main effects	10802.8	19	57.02***
	Time (weeks)	10295.9	16	64.53***
	Centre	6.1	1	0.61
	Weight (covar)	936.6	1	93.92***
	Lot size (covar)	113.3	1	11.36***
	Residual	4726.4	474	
	Total	15529.2	493	$R^2 = 0.70$
Cow category no. 2	Main effects	2869.0	11	87.47***
	Time (weeks)	2851.5	8	119.53***
	Centre	0.1	1	0.04
	Weight (covar)	6.9	1	2.30
	Lot size (covar)	17.2	1	5.78**
	Residual	480.1	161	
	Total	3349.1	172	$R^2 = 0.86$

TABLE A.3

The Effect of Lot Size and Number of Buyers on Prices at the Large and Small Centres

Cattle type	Source of variation	Large centre			Small centre		
		Sum of squares	Degrees of freedom	F	Sum of squares	Degrees of freedom	F
Steer category no. 1	Main effect	10184.1	18	26.81***	4084.5	18	9.12***
	Time (weeks)	8632.0	15	27.27***	3767.5	15	10.09***
	Weight (covar)	518.8	1	24.58***	146.3	1	5.88**
	Lot size (covar)	256.1	1	12.14***	149.0	1	5.99**
	No. of buyers (covar)	20.1	1	0.95	0.0	1	0.00
	Residual	5824.6	276		3236.0	130	
	Total	16008.7	294	$R^2 = 0.64$	7320.6	148	$R^2 = 0.56$
Steer category no. 2	Main effects	7993.2	13	49.81***	2027.0	12	13.51***
	Time (weeks)	7953.4	10	64.45***	1910.2	10	16.55***
	Weight (covar)	17.5	1	1.42	189.9	1	16.46***
	Lot size (covar)	63.8	1	5.20**	34.5	1	2.99*
	No. of buyers (covar)	0.0	1	0.00	0.0	1	0.00
	Residual	2098.4	171		657.6	57	
	Total	10091.6	183	$R^2 = 0.79$	2684.5	70	$R^2 = 0.76$

Cattle type	Source of variation	Large centre			Small centre		
		Sum of squares	Degrees of freedom	F	Sum of squares	Degrees of freedom	F
Cow category no. 1	Main effects	7114.4	19	51.63***	4125.4	19	15.56***
	Time (weeks)	6711.9	16	57.39***	3815.9	16	17.10***
	Weight (covar)	487.4	1	66.67*	356.0	1	25.52***
	Lot size (covar)	150.9	1	20.64***	1.6	1	0.11
	No. of buyers (covar)	0.0	1	0.00	0.0	1	0.00
	Residual	2313.5	316		1939.2	139	
	Total	9427.9	334	$R^2 = 0.76$	6064.6	158	$R^2 = 0.68$
Cow category no. 2	Main effects	1779.9	11	150.50***	1161.8	11	17.49***
	Time (weeks)	1519.6	8	117.98***	1042.1	8	21.57***
	Weight (covar)	1.7	1	1.03	13.5	1	2.23
	Lot size (covar)	23.0	1	14.29***	8.2	1	1.35
	No. of buyers (covar)	0.0	1	0.00	0.0	1	0.00
	Residual	182.4	113		211.6	35	
	Total	1962.3	124	$R^2 = 0.95$	1373.3	46	$R^2 = 0.85$