BEEF QUALITY PREFERENCES IN WESTERN AUSTRALIA

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Abstract

A declining per capita consumption of beef and veal in Western Australia has encouraged an interest in the better matching of supply to consumer needs. Consumers' preferences for quality attributes of goods is reflected in the price consumers pay for the goods. These preferences may be transmitted backwards through each stage of the marketing channel and are reflected in the prices producers receive for goods of different quality. Producers are therefore encouraged to tailor these products to meet consumer preferences.

Hedonic price analysis, a technique for analysing consumer preferences for quality attributes, is applied to different stages of the marketing channel, ie producer-wholesaler and wholesaler-retailer.

A close correspondence in quality-related price differentials at the various levels of the marketing channel would indicate the possibility for efficient communication of price signals from consumers to producers.

A sample of 516 cattle and carcasses has been chosen over a period of five weeks during winter and spring. Cattle are individually identified and their progress from live auction to carcass sale is studied with information collected as to selected quality characteristics and the prices.

In this paper, the price of cattle has been hypothesised to be a function of liveweight, breed, nutrition, buying source, age, sex, fat depth, season, and location of abattoir; while the carcass price is explained by carcass weight, nutrition, age, sex, fat depth, fat and meat colour, fat and meat texture, bruising, season, and location of abattoir.

The preliminary analysis indicated that weight, buying source, age, sex, fat depth, colour, texture, bruising and season are important characteristics for determinants of price.

Introduction

Since the mid-1970s the number of cattle slaughtered and beef production in Western Australia have been declining because of a reduction in the population of beef cattle (Table 1). One reason for this is a shift into the more profitable alternative enterprises in the agricultural area (Peggs 1989).

Table 1: Number of beef cattle, cattle slaughtered, beef production, consumption and per capita consumption in Western Australia (selected years)

	Number of beef cattle	Number of cattle slaughtered	Beef production (tonnes)	Consumption		Per capita consumptn (kg)
				Domestic ('000 t)	Export ('000 t)	
1977	2 312 510	848 000	148 149	76.0	84.3	63.5
1980	1 937 559	663 000	126 578	58.0	58.2	45.7
1983	1 631 900	662 000	120 202	50.4	40.4	34.5
1988	1 509 200	492 000	100 870	54.7	46.2	35.4

Domestic consumption and exports decreased by 21 and 38 per cent respectively from 1977 to 1988. This resulted in a fall in total beef

from 63.5 kg in 1977 to 35.4 kg in 1988. If this decline is due to the change in taste and preferences of the consumer, the producers will have to counteract this effect by offering a quality of beef and veal which matches consumer preference.

Efforts have been made to facilitate this. The carcass classification scheme, a standardised grading system for beef, was proposed by the Australian Meat Board in 1972 with the main objective of providing information about the important physical characteristics of carcasses such that both buyers and sellers can estimate, sight unseen, the value of carcasses to their operation. Under this scheme, pricing efficiency can be expected because the preferences of consumers are transmitted through the marketing system to the producers and reflect in the prices producers receive for goods of different quality.

The purpose of this study is to identify the preferred cattle and carcass quality characteristics in the meat marketing system in Western Australia.

The Model

Hedonic Price Model

The hedonic technique was developed by Griliches (1971) in order to remove quality changes from time series price indexes. Later on, Lancaster (1971), Rosen (1974) and Lucas (1975) provided the theoretical model for the hedonic approach.

The hedonic hypothesis states that goods are valued for their utility-bearing characteristics (Rosen 1974) and the price of goods varies directly with the specific amounts of each characteristic the good contains. In traditional economic theory of consumer demand, the assumption of homogeneous goods is made and, therefore, does not view the true relationship between the intrinsic qualities of a good and the consumer's utility from that good.

The hedonic model specifies a unit of each good as a vector of characteristics and includes a transformation function from characteristics to utility. In this manner, the hedonic model can be incorporated directly into the traditional utility maximisation model.

The hedonic price function can be represented as (Rosen 1974):

$$P(x) = Z(Z_{i1}, \ldots\ldots Z_{in})$$

where P(X) = observed price of commodity x
Z = amount of commmodity's characteristics.

Empirical hedonic analyses, especially in the case of agricultural products, follow the work of Ladd (1978) as well as Ladd and Martin (1976) and Ladd and Suavannunt (1976). Recent applications of the hedonic approach to agricultural commodities include cotton (Ethridge and Davis 1982), malting barley (Wilson 1984), rice grain (Brorsen 1984, Unnevehr et al 1985), greasy wool (Bramma, Curran and Gilmour 1985), tomato (Jordan et al 1985), wheat (Veeman 1987), alfalfa hay (Pardew 1988) and soybean seed (Houston and Jeon 1988).

Marketing Channel

In commodity marketing, goods flow from producers to consumers via a series of intermediaries. There are a number of alternative flows possible. These alternative flows are called "marketing channels" (Kohls and Uhl 1980). In Western Australia cattle are sold from the farm, either by auction (including electronic auction (CALM)) or direct sale to the wholesaler.

government abattoirs and distribute to retailers mainly in the form of chilled carcasses. At the retail level beef and veal are sold predominantly as chilled cuts. The beef and veal marketing channel can be divided into three different levels: producer-wholesaler level, wholesaler-retailer level, and retailer-consumer level.

In order to investigate whether consumer preferences for beef and veal quality characteristics are being efficiently transmitted to the producer along marketing channels, comparisons of price quality relationships between these three different levels are being considered. Close correspondence in these different levels would indicate efficient transmission of quality-price information.

Live cattle are the traded commodity at the producer-wholesaler level and carcasses are the traded commodity at the wholesaler-retailer level. Problems arise, however, at the retailer-consumer level where the traded commodity can be in a vast array of forms ranging from separate cuts and offal to part carcasses. This study, therefore, concentrates only on the producer-wholesaler level and the wholesaler-retailer level. The retailer-consumer level is excluded due to the problem mentioned earlier, and the assumption that retailer demand is a derived demand which reflects consumer tastes and preferences.

With the exception of Todd and Cowell (1981), little work has been done to compare quality-price relationships at different levels of the marketing channels or to investigate pricing efficiency, and quality and price information transmission. Todd and Cowell (1981) examined price variability within cattle and carcass auction sales. Time of sale, breed, district of origin of cattle, sex, carcass weight, fatness, lot size, and joint relationship between age and weight were found to influence significantly price variation within the cattle auction, while fatness, sex, and a weight and fat interaction term were found to be statistically significant explanators of carcass auction price. Among these variables, sex and fatness provided a consistency within livestock auction and carcass auction.

Beef and Veal Model

Most studies of meat consumption have involved analyses of price (Stent 1967, Papadopoulos 1977, Naughtin and Quilkey 1979, Mackaren 1977, Cowell and Todd 1980), demand (Marceau 1967, Armington 1969, Colman and Miah 1973), and marketing margins (Holdren 1960, Griffith 1974, Griffith Freebairn and Whitelaw 1974). Little consideration had been given to the interesting question of the price and quality relationship.

Beef and veal are heterogeneous products, made up of many structural, physiological and biological characteristics such as conformation, muscle fibres, colour, texture, etc. Beef and veal price is affected, therefore, by the desires of consumers and their quality evaluations.

Lund, Duewer, Maki and Strand (1968) employed a five-point hedonic scale to measure consumer opinion on physical characteristics of meat in Iowa. Results showed that freshness, colour and fat content were important while amount of bone was of least importance.

Beef and veal go through the marketing channel in different forms. At the producer-wholesaler level live cattle are traded while at the wholesaler-retailer level the carcass form is traded. Price and quality relationship of beef and veal at producer-wholesaler level was studied by Cowell and Todd (1980), Hall (1981), Keane and Riordan (1973), Todd and Cowell (1981) and Williams, Longworth and Whan (198). At wholesaler-retailer level, O'Connell (1981 1986), Park (1979) and Porter and Todd (1985) have contributed.

The quality characteristics likely to be important, such as weight, age, sex and fat depth and which often appear in the carcass classification schemes, have been included in the analysis of many researchers.

Weight

Liveweight alone gives the best single estimate of body composition within a breed, sex or age group (Tulloh 1963). With increasing weight, changes occur in the body composition of cattle. Thus the proportion of meat in cattle rises as a function of increased weight. Liveweight was found to be a significant explanator of cattle prices by Keane and Riordan (1973), Park (1979), Todd and Cowell (1981) and Williams (1989).

Carcass weight is often considered to determine the size of certain cuts of meat, eg rumps and T-bones, and thus influences suitability of the carcass for markets showing different preferences for size of cuts. Studies by O'Connell (1981 1986), Cowell and Todd (1980), Todd and Cowell (1981), and Porter and Todd (1985) showed that carcass weight significantly influenced the carcass price.

Age

Age is an important factor determining the tenderness, flavour and colour of meat. It has an effect on the value of the carcass (McIntyre 1982).

At the producer-wholesaler level, Keane and Riordan (1973) and Park (1979) found that there was no indication that teeth numbers, as a measure of age, had an effect on price. However, Park's results showed that age and the dressing percentage interaction term was significant; whereas Todd and Cowell (1981) found that both age and an age and weight interaction were explanators of price variation.

At the wholesaler-retailer level, age was a significant explanator of carcass auction price (Todd and Cowell 1981, Hall 1981, Porter and Todd 1985).

Sex

The carcasses of steers yield higher proportions of edible meat than heifer carcasses (Preston and Willis 1970). This is due to higher amounts of fat in heifers than in steers at the same carcass weights (Wythes and Ramsay 1979, McIntyre and Frapple 1985, Everett and Evans 1970), and results in the traditional price discount for heifers relative to steers.

Beef from bulls has a strong flavour and colour. It also has high water retaining and absorbing properties. Hence the end use of this meat is for processed meats such as hamburger mince, and differs from the end use of steers and heifers which is as table beef.

Previous research has shown that at the producer-wholesaler level sex was a determinant of cattle prices with a premium paid for steers (Todd and Cowell 1981). The same result presented at the wholesaler-retailer level by Hall (1981) and Cowell and Todd (1980). Even though Porter and Todd (1985) found that sex was a significant explanator of carcass price, steers were discounted relative to heifers. Todd and Cowell (1981) did not find the sex of the cattle to be important in explaining prices.

Fat Thickness

The proportion of fat is the most important single factor determining the yield of saleable meat. Too much fat is waste due to its low commercial value and high cost of trimming. Similarly, too little fat can affect the acceptability and eating quality of the meat. A carcass without adequate fat

cover chills more quickly and may result in toughening of the meat (Wythes and Ramsay 1979).

Fat thickness was found to be a significant explanator for both cattle prices (Park 1979, Williams 1989) and carcass prices (O'Connell 1981 1986, Cowell and Todd 1980, Todd and Cowell 1981, Porter and Todd 1985).

Besides the characteristics on the carcass classification tickets, researchers also examined other characteristics such as breed, fat and meat colour, fat and meat texture, nutrition, bruising, lot size, district of origin, time of sale, etc.

Breed

Wythes and Ramsay (1979) found that animals of all breeds follow the same basic development pattern for bone, muscle and fat. In terms of eating quality, differences are rare amongst breeds (Barker 1982). However, Todd and Cowell (1981) found that breed was a significant explanator of livestock price variations. They suggested that, before any firm conclusions could be made, further research was needed covering more breeds. Hall (1981) found that dairy breed characteristics were significant in auction price determination.

Nutrition

Due to a different gut-fill between the two types of diet (McIntyre 1982), at the same liveweight animals fed on a diet containing a high proportion of grain have higher carcass weight than those fed on pasture. Grain feeding relative to grass feeding has been found to be a significant explanator of price variation in both producer-wholesaler level (Porter and Todd 1985) and wholesaler-retailer level (Williams 1989) with the premium paid by the buyers.

Meat and Fat Colour

The colour of meat depends on the chemical form and amount of myoglobin present as well as the degree of acidity (Wythes and Ramsay 1979). It is also affected by the species, sex and age of the animal. Stress prior to slaughtering also plays a significant role in meat colour.

Fat colour of beef carcass ranges from white to yellow. yellow fat is a characteristic of some dairy breeds, green pasture fed cattle, and an indication of advancing age.

Meat colour may account for some of the variation in carcass prices with dark coloured meat discounted by retailers (O'Connell 1981 1986, Porter and Todd 1985). The retailers discounted the price for yellow fat.

Meat and Fat Texture

It is accepted that texture is closely related to tenderness, colour and acidity (Cook 1964). Meat and fat texture were included in the estimating equation by Porter and Todd (1985). None of them was found to be significant.

Bruising

Bruises result in two types of losses: (a) the bruised carcass area is trimmed out with corresponding lost value of that part, and (b) the remaining carcass is devalued (Williams and Stout 1964).

A bruising score was estimated by O'Connell (1986), Todd and Cowell (1981) while Porter and Todd (1985) specified bruising as a dummy variable. In the first two of these studies bruising was found to influence carcass

price with discounts for the bruised carcasses. Porter and Todd (1985) found that bruising was not significant.

Lot Size, Place and Time

In their beef and veal models, Keane and Riordan (1973) and Todd and Cowell (1981) found that lot size, place of sale and time of sale were significant explanators for cattle price. Williams (1989) also found that lot size and time of sale variable are significant at the producer-wholesaler level.

Carcass price variation at the wholesaler-retailer level was explained by lot size (Hall 1981, Todd and Cowell 1981), district of origin (Todd and Cowell 1981, O'Connell 1981 1986), auction centre (Hall 1981) and time of sale (Porter and Todd 1985).

Model Specification

In this study hedonic price functions have been estimated. The hedonic price model assumes that goods are valued for their utility-bearing characteristics and that the prices of goods vary with the specific amounts of each characteristic contained (Rosen 1974). The heterogeneous nature of beef and veal can be interpreted as a bundle of utility-bearing characteristics upon which consumers bid. The hedonic model, therefore, forms a suitable basis for this study. Consequently, the general hedonic price model of beef and veal in Western Australia may be expressed as:

1. At the producer-wholesaler level:

$$LP = f(LW,A,S,FD,N,BR,SO,SE,PL)$$

2. At the wholesaler-retailer level:

$$CP = f(CW,A,S,FD,N,MC,MT,FC,FT,BU,SE,PL)$$

where

LP = cattle price (¢/kg)
CP = carcass price (¢/kg)
LW = liveweight (kg)
CW = carcass weight (kg)
A = age (dentition)
S = sex
FD = fat depth (mm)
N = nutrition
BR = breed
SO = source of buying
SE = season
PL = location of abattoir
MC = meat colour
MT = meat texture
FC = fat colour
FT = fat texture
BU = bruising

Data

Primary data used in the study were collected during two 5-week periods at saleyards and abattoirs in Perth during the winter and spring of 1989. An abattoir in Busselton was included during spring 1989. Not all participants in the industry were willing to be involved. Data were therefore collected from two wholesale companies, both of whom are involved in various meat marketing activities such as purchasing from the farmers and auction, processing and selling to the retailers.

The same animals were tracked from producer-wholesaler level to wholesaler-retailer level to obtain accurate correspondence between these levels of the marketing channel.

Specification of Variables

Price

Cattle and carcass prices were collected from livestock sold at the live auction or direct sale from the farmer. Carcass prices were collected from carcasses sold at the abattoir. All prices were recorded in ¢/kg.

Weight

Liveweight was recorded from cattle sold at auction; otherwise it was calculated from the carcass weights described on the carcass classification tickets. Fifty-four per cent was taken as the dressing percentage (wholesaler, personal communication). All carcass weights recorded in this study were on a hot weight basis, taken immediately after the dressing operations.

Both liveweight and carcass weight were included in the model as continuous variables.

Age

Age influences the tenderness, flavour and colour meat. Beef is still relatively tender at about eighteen months to two years of age. Both flavour and toughness increase appreciably by three years of age (McIntyre 1982). Age was assessed by dentition.

In this model age is categorised as a dummy variable with zero for no permanent incisors and one for the presence of permanent incisors.

Sex

The sex of the animal is a source of considerable price differential in the market place despite the fact that the sex of the animal has little or no effect on eating or processing quality (Randles 1982).

Animals are classified as steer, heifer or bull, and sex has been specified as a dummy variable.

Fat Depth

The most commonly used site for fat measurement in the early research was over the eye muscle at the 12th/13th rib (Cowell and Todd 1980, Todd and Cowell 1981, Porter and Todd 1985). The Authority for Uniform Specification of Meat and Livestock (AUS-MEAT) has subsequently selected the P8 site" on the rump to indicate fatness. The P8 site measurement position is not damaged to the same extent as the 12th/13th rib, and has a similar yield (Hall 1988).

The data on fat depth as well as the carcass weight, age and sex were recorded in millimetres at the P8 site on the carcass classification ticket and the kill sheets sent back to the farmers.

Nutrition

There is a common misunderstanding that cattle fed grain are of better quality than those fed pasture or forage. This probably originated from the fact that cattle fed grain often grew faster and finished younger than those grazing pasture (Baker 1982).

Breed

Breeding strongly affects the body composition and the age and weight at which cattle will fatten. Hence the maturity type of the cattle is of great importance in breeding programmes and is expected to influence purchasers of livestock for slaughtering.

Different breeds were categorised into three maturity types: early maturing, late maturing and intermediate maturing. They were included in the model as a dummy variable.

Meat and Fat Colour

Bright red meat is usually preferable for table beef but darker colours tend to be rejected by consumers since they may come from old, sick, fatigued or stressed animals (Wythes and Ramsay 1979).

Fat colour is of little nutritional significance to consumers, but it is reported by butchers that consumers display a preference for white fat.

Meat colour was measured in the chuck area whereas fat colour was averaged from the shoulder, loin, chump and leg, using the WA Department of Agriculture meat and fat colour codes. There were six colours for meat, ranging from pink (No.1) to dark red (No.6), and for fat ranging from white (No.1) to yellow (No.5). These characteristics were represented by dummy variables.

Meat and Fat Texture

Little is known about the influence of meat texture upon eating preferences. According to the butcher, consumers generally prefer hard and smooth texture in both meat and fat.

Meat and fat texture were assessed subjectively and specified as a scale variable: 1 (fine), 2 (medium) and 3 (course).

Bruising

Bruised carcasses are a source of loss in returns, particularly to the retailers. Rickenbacker (1959) stated that the largest losses were in the hip or loin area, while shoulders accounted for the second highest loss. Bruising can occur when cattle are handled in different ways between mustering and slaughter.

The bruising variable was specified according to the presence of absence of bruising.

Season and Location of Abattoir

Ladd (1971) contended that product characteristics not only mean those characteristics and properties that are inherent in the product, but also mean the various kinds of selling effort, and services associated with ownership and use of the product. Consequently, season and location of abattoir, although not related directly to quality attributes of the cattle and carcass, were included in the equation.

Season: Seasonal variation in cattle and carcass prices are influenced by seasonal variations of livestock marketings and slaughter numbers. Cattle production and cattle numbers turned off for slaughtering vary at different times of the year. Scarce supply and high quality carcass cause high prices in winter. Price correspondingly falls in summer due to excess supply of grass-fed cattle. Seasonal dummy variables were used in the estimating equations.

Location of abattoirs: Variations of the price for different abattoir sites were anticipated, since they provide indications of the cattle and carcasses transportation costs, costs of slaughtering and different slaughtering techniques. Abattoirs in perth and Busselton are the samples in this study and were specified as a dummy variable.

All the variables except fat and meat texture were objectively measured. The texture was subjectively measured.

To overcome the problem of linear dependency in the regression specification and to allow parameters of the model to be estimated (Porter and Todd 1985), it was necessary to remove the following reference variables associated with the dummy variables, as below:

Removed reference variables	Associated dummy variables
presence of permanent incisor	age
heifer	sex
grain fed	nutrition
late maturing type	breed
auction sale	source of buying
meat colour code 4	meat colour
fat colour code 1, 2, 3	fat colour
scale 3 (coarse)	meat texture
scale 3 (coarse)	fat texture

The estimated results are interpreted as relative to the removed reference variables.

Results and Discussion

The model specified was estimated for two different market levels: producer-wholesale level and wholesaler-retailer level, using an Ordinary Least Squares (OLS) procedure available in SHAZAM Version 6. No economic theory can specify the form of the estimating equation. Consequently, both linear and nonlinear forms were tried. In the latter case, the continuous variables of liveweight (LW), carcass weight (CW) and fat depth (FD), which were each expressed in quadratic form, gave a better degree of fit of the equation to the data.

Multicollinearity was evident among the variables of meat colour, fat colour, nutrition and season. To overcome this problem only one of the colours which has multicollinearity and season was selected to fit the equation.

Autocorrelation was present in both equations. This was corrected, using a Cochrane-Orcutt iterative procedure. The results for both equations are present in Tables 2 and 3 respectively.

Producer-Wholesaler Level

The explanatory power of characteristics on cattle price variation was 79 per cent for the quadratic equation. A quadratic form best described the relationship between price and weight. The negative relationship is consistent with the work by Keane and Riordan (1973) and Park (1979) who studied the domestic market. The results showed that an increase of 1 kg in cattle weight led to a decrease of 0.06¢/kg. This result applied to the data range of heavy cattle which are not preferred by buyers.

From the quadratic term an optimal liveweight was calculated. The result suggested the optimal liveweight of 528 kg. Cattle whose weight is less or greater than this optimal level are not preferred. The liveweight contributed 10.86 per cent to the variation in cattle price.

Table 2: The estimation results for producer-wholesaler level

Quality variables	Coefficients	Standard error	T-value
Liveweight	-0.0634	0.0144	-4.3974***
(Liveweight)^2	0.00006	0.00001	4.2083***
Sex: Steer	0.9589	0.5595	1.7139**
Bull	-7.7524	1.9597	-3.9558***
Fat depth	1.5800	0.1537	10.2780***
(Fat depth)^2	-0.0794	0.0066	-12.0030***
Breed: early maturing	3.3184	1.4590	2.2711**
intermediate maturing	3.0351	1.7783	1.7067**
Source of buying: farmer	9.2870	1.4707	6.3148***
Season: winter	11.4290	2.2647	5.0467 ***
Location of abattoir: Perth	9.2143	2.2619	4.0737***
Constant	120.8900	4.2568	28.3990

$\bar{R}^2$ = 0.7867
F = 173.67
N = 516
DW = 2.2608

Significant level: *** = 0.01
** = 0.05
* = 0.10

Table 3: The estimation results for wholesaler-retailer level

Quality variables	Coefficients	Standard error	T-value
Carcass weight	-0.1598	0.0113	-14.0960***
Sex: steer	2.3180	0.9526	2.4333***
Fat depth	3.3079	0.2784	11.8820***
(Fat depth)^2	-0.1727	0.0121	-14.2300***
Meat colour: code 3	1.7095	0.9561	1.7879**
code 5	-3.9835	2.3796	-1.6740**
Fat colour: code 4	-3.5951	1.2868	-2.7938***
Meat texture: fine	2.1406	0.9602	2.2294***
Bruising	-12.3220	1.8567	-6.6364***
Season: winter	23.8430	1.9861	12.0050***
Constant	269.7800	2.8769	93.7750

$\bar{R}^2$ = 0.7875
F = 191.85
N = 516
DW = 2.1610

Significant level: *** = 0.01
** = 0.05
* = 0.10

Sex was found to be a significant explanator of price variation. A premium of 0.96¢/kg was paid for steers. Bulls were discounted by 7.75¢/kg in comparison with heifers. A premium for steers relative to heifer is consistent with Todd and Cowell (1980).

Bulls are only a small proportion of the cattle traded in the sample since the sample companies prefer table beef.

Fat depth was found to be a significant explanator of cattle prices. The relationship was best described by a quadratic form. Each increase of 1 mm in fat depth increased the price by 1.58¢/kg. This positive relationship is consistent with the results in Todd and Cowell's study (1981).

The positive relationship applied to only a certain range of the fat depth. The majority of the data (55 per cent) ranges between 7 to 12 mm with the average sample mean fat depth of 8 mm. The cattle fat depth which falls into this range attracts a premium price from the buyers. Outside this range, a negative relationship would be expected. According to the wholesaler, very lean and very fat cattle are not preferable.

An optimum level of fat depth of 9.94 mm was derived from the quadratic form. Fat depth contributed 5.56 per cent to the cattle price.

Breed was found to be a significant explanator of cattle price. Wholesalers paid a premium of 3.31¢/kg on early maturing types (Angus, Hereford, Shorthorn and Murray Grey) and 3.04¢/kg on intermediate maturing types (Santa Gertrudis and cross breeds) relative to late maturing types of cattle (Friesien, Charolais, Simmental and Limousin). this result is consistent with the work done by Todd and Cowell (1981). However, they compared only Hereford to Shorthorn, which are classified as early maturing types in this study.

Source of buying is another significant explanator of cattle price. Direct buying from the farm appeared to have a positive effect on price. This result is consistent with Cowell and Todd (1980) and Frapple (1989). From this analysis, the premium of 9.29¢/kg was paid for livestock bought direct from farmers relative to those from auction. Based on the average liveweight of the data, farmers received a premium of $32.24/head.

The location of the abattoir was found to be a significant explanator of cattle price variation. A premium of 9.21¢/kg was applied to the abattoir in the Perth area relative to the Busselton area. The observed price difference reflects the higher transportation cost from farm to abattoir.

Age and nutrition were not found to be significant explanators of cattle prices.

In a livestock auction, there is no direct indication of age. Buyers use their experience to assess the age of the cattle. Keans and Riordan (1973) concluded that age as measured by dentition appeared to have very little effect on price.

Seasonality and cattle price were positively correlated. Cattle sold in winter attracted a premium of 11.43¢/kg relative to prices paid in spring. Shortage of supply accounts for the observed result.

Wholesaler-Retailer Level

At the wholesaler-retailer level (Table 3) 79 per cent of the variation in carcass prices was explained by the model. The variables on carcass classification tickets were all important in explaining carcass price variations.

Carcass weight and carcass price were negatively correlated. An increase in 1 kg of carcass weight resulted in a decrease in carcass price of 0.16¢/kg. This relationship indicated that heavy carcasses were less suitable for the local retail market, as they did not match consumer requirements for the size of cuts (Randles 1982). The carcass weight variable contributed 11.29 per cent to the carcass price.

Steers yielded a higher carcass price than bulls, attracting a premium of 2.32¢/kg. This result was consistent with that obtained at the producer-wholesaler level and with the study of Todd and Cowell (1981).

Fat depth has a positive influence on the carcass price and contribute 5.79 per cent. An increase in fat depth of 1 mm increased the carcass price by 3.31¢/kg. The optimum fat depth calculated from the quadratic term was 9.58 mm.

Meat colour, fat colour and meat texture were found to be significant explanators for carcass prices. On the assumption that retailers may not be able to discriminate six different colours for meat and five colours for fat, aggregated meat and fat colours were employed in the estimating equation. However, the aggregated variables did not yield satisfactory results. The original colours were reconsidered and used in the equation, except for those with multicollinearity problems (colour codes 1, 2, 3 for meat and 1, 2, 3 for fat) which are aggregated.

The meat colour codes 3 and 5 were found to be significant explanators of carcass price. In comparison with "red" (colour code 4), colour code 3 had a premium of 1.71¢/kg, whereas colour code 5 was discounted by 3.98¢/kg. These results are consistent with survey results (Wilson and Wisseman 1981), and research results (Porter and Todd 1985) which suggested that retailers considered meat colour as a major factor in buying carcasses.

Fat colour code 4 was discounted by 3.60¢/kg in comparison with white fat (colour codes 1, 2, 3). This results was consistent with O'Connell (1981 1986) and Porter and Todd (1985).

Meat texture is important, with fine meat texture attracting a premium of 2.14¢c/kg relative to coarse meat texture.

Bruising was another factor which was found to influence the price paid. A carcass with bruises was discounted by 12.32¢c/kg. This result was consistent with O'Connell (1986), Todd and Cowell (1981) and Porter and Todd (1985).

Seasonality was also found to be a significant explanator of carcass prices. Buyers paid premiums of 23.84¢c/kg in winter relative to price paid in spring. Shortage of supply and high quality, grain-fed carcasses in winter account for the observed result.

A joint relationship between age, weight and fatness was suggested by Preston and Willis (1970). Bouton et al (1978) also suggested age-weight interaction terms. In this study, the interaction terms were found to be insignificant explanators of both cattle and carcass prices.

Conclusion

From the preliminary analysis of the model it is evident that a large number of characteristic factors affect the price of beef significantly both at the producer-wholesaler level and wholesaler-retailer level.

It was notable that 79 per cent of the variation in both cattle and carcass prices was accounted for by the model. The variables on carcass classification tickets, except for age, were significant at both levels. This implies that information on the carcass classification ticket was

transmitted from retailers back to producers. Consequently, it could be concluded that, to meet the consumer demand for specific characteristics, farmers should produce steers with a liveweight of 528 kg and fat depth of 9.94 mm.

The positive relationship between the early maturing types and cattle prices suggested that Angus, Hereford, Shorthorn and Murray Grey were the preferred breeds on which farmers in the south west of Western Australia should concentrate. Farmers benefit by selling their cattle directly to the wholesalers rather than selling through the auction centres. Producers dealing with the abattoir in Perth incur higher transportation costs than those delivering to the Busselton abattoir. Transportation costs will be scrutinised in the next stage of this study.

Carcasses from steers with fat depths of 9.6 mm were preferred by retailers. The fat depth variable was consistent at both levels. Nevertheless, the coefficient at the wholesaler-retailer level is greater than at the producer-wholesaler level and can be accounted for in the method of assessment, that is actual trimmed carcass displayed to buyers versus visual inspection of the cattle on a "fat in" basis.

The size of the discount price in liveweight and the premium price in fat depth in the producer-wholesaler level is different from those in the wholesaler-retailer level. However, the percentage of contribution of weight to price in these two market levels is similar, with a higher percentage of fat depth in the wholesaler-retailer level.

The carcasses with meat colour code 3 and fat colour code 1, 2 or 3, with fine meat texture and without any bruising, attracted premium prices from the buyers.

These results apply only to winter and spring data. Data for summer and autumn are yet to be collected to complete the model. Pricing efficiency in the two levels of the markets will be examined in the next stage of this study.

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