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# **The political economy of quality measurement: a case study of the USA slaughter cattle market\***

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As agricultural products move from being economic commodities to quality-differentiated goods, price dispersion within specific markets increases and implicit subsidies from high quality producers to low quality producers are removed. The present paper examines how these distributional effects can influence patterns of support and opposition to changes in marketing arrangements. The simple model developed is calibrated using data from the USA slaughter cattle market. Estimates of the impact on prices of measuring quality more accurately are found to be similar in size to previous estimates of market power price suppression in the market.

## **1. Introduction**

The level of quality measurement and the use of this information in price determination in many agricultural markets have increased during the last decade. Examples include measurements of staple length and fibre diameter in wool markets, baume and colour in wine grapes (e.g. using near-infra-red spectroscopy and other technological advances), meat marbling and yield in slaughter livestock markets (e.g. Meat Standards Australia), and many more. The notion of agricultural goods being homogeneous commodities is of declining relevance as quality differentials become reflected in large price differentials. This can have distributional effects within the group of sellers in a market if sellers differ in their average quality.

There are many possible reasons why quality differentials may be emerging as economically significant factors in price determination now after such a

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long period of being largely ignored. As income levels (exogenously) rise, it is likely that consumers will become more discriminating in their food purchases.<sup>1</sup> As national agricultural markets increase in size and national markets converge with markets of other countries to produce global markets, opportunities for further product specialisation and differentiation arise. As computers, lasers, digital cameras, ultrasound equipment, and other measurement and data management devices become cheaper, the costs of quality measurement decline.

In addition to these (economic) efficiency-driven reasons for the recent increases in levels of quality measurement in agricultural markets, the concurrent increase in concentration in many agricultural processing sectors has raised concerns that quality measurement could be a mechanism for the exercise of monopsony market power by processors. Many actual and proposed increases in quality measurement have met opposition from producer groups who claim the changes are designed to separate producers (multimarket price discrimination) or suppress price (monopsony power). Although these concerns are real and must be examined thoroughly, a nagging problem with the opposition from producer groups is that it is often producers themselves that initiate marketing alternatives based on quality measurement. In addition, processors (the supposed beneficiaries of this exercise of market power) are often reluctant to become involved with the changes and they only do so after sustained producer lobbying.

The present paper examines the distributional effects of pricing on a quality basis using a simple model of imperfect quality measurement. The first section develops this model and uses it to demonstrate why both support and opposition to increased quality measurement can come from producers (sellers) while processors (buyers) remain indifferent to the level of quality measurement. The second section introduces the USA slaughter cattle spot market and calibrates the model to this market. The third section examines an alternative marketing channel that has emerged in the slaughter cattle market that uses a higher level of quality measurement in price determination. The fourth section briefly reviews the market power debate that has evolved in the USA slaughter cattle market, and the fifth section tests if quality differentials alone can account for previous empirical estimates of price effects that were attributed to market power. Concluding remarks on quality and future research follow.

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<sup>1</sup> The literature estimating income elasticities for quality traits is still rather small, but the available evidence does indicate that they tend to be positive. See Gandil (1996) for estimates on quality traits in housing, Vakil and Russon (1996) for air transport, and McConnell (1997) for a review of estimates on environmental quality traits.

## 2. Distributional effects of quality measurement

The key assumption of the present paper is that, in addition to quality heterogeneity within a farm, there is quality heterogeneity across farms. Some producers, whether from differential managerial talent, land quality and weather conditions, past investment decisions in genetics and management, quality price premiums or any other reason, have higher average quality agricultural products than other producers. When quality is not measured, or is measured with a high degree of inaccuracy, the market determines an average price over quality and high quality producers are implicitly subsidising low quality producers. An increase in the level of quality measurement used in price determination removes some or all of this implicit subsidy by raising the average price that high quality producers receive and lowering the price low quality producers receive. Overall market average price remains constant as long as there is no endogenous increase in market average quality in response to higher quality premiums.

To formalise this notion, Akerloff's (1970) model of imperfect quality measurement is used. Hennessy (1996) develops a concise version of this model for use in agricultural markets and his notation (with slight modification) will be adopted. There are two qualities in the model, and as the USA slaughter cattle market will be used for estimation, these are denoted "choice" (good) and "select" (bad). There are two types of measurement error that can occur – a choice product can be graded select, and a select product can be graded choice. The probabilities of these errors are labelled  $u_{S|C}$  and  $u_{C|S}$ , respectively. These error probabilities reflect the level of quality measurement (they are technological parameters), and an increase in the level of quality measurement is reflected by a decrease in the error probabilities.

The fraction of total marketings that are choice for a given marketing period is denoted  $\lambda$  (in the USA slaughter cattle market, marketing and price discovery occur weekly). With  $\lambda$ ,  $u_{S|C}$ , and  $u_{C|S}$ , two additional probabilities can be defined – the probability that a product that grades choice is actually select, and the probability that a product that grades select is actually choice. These probabilities are labelled  $\pi_{S|C}$  and  $\pi_{C|S}$ , respectively. Expressions for these can be derived as follows:

$$\pi_{S|C} = \frac{(1 - \lambda)u_{C|S}}{\lambda(1 - u_{S|C}) + (1 - \lambda)u_{C|S}} \quad (1A)$$

$$\pi_{C|S} = \frac{\lambda u_{S|C}}{(1 - \lambda)(1 - u_{C|S}) + \lambda u_{S|C}}. \quad (1B)$$

These expressions simply state that the probability of a product that grades choice actually being select is the fraction of select product that grades choice

divided by the total fraction of product that grades choice. Similarly, the probability of a product that grades select actually being choice is the fraction of choice product that grades select divided by the total fraction of product that grades select. Notice the difference between the two sets of probabilities,  $\pi_{S|C}$  and  $\pi_{C|S}$  are (endogenous) *ex post* conditional probabilities describing the level of grading error that has occurred (and derived by Bayes' Rule) while  $u_{S|C}$  and  $u_{C|S}$  are *ex ante* technological parameters describing the degree of measurement error.

The processor (buyer) has some valuation of choice and select derived from their output market. These valuations are labelled  $v^C$  and  $v^S$ , respectively. The value of a product that grades choice to a processor is  $v^C(1 - \pi_{S|C}) + v^S\pi_{S|C}$  and the value of a product that grades select is  $v^C\pi_{C|S} + v^S(1 - \pi_{C|S})$ . In a competitive market the prices for choice and select will be driven to these valuations:

$$P^C = v^C(1 - \pi_{S|C}) + v^S\pi_{S|C} = v^C - \pi_{S|C}(v^C - v^S) \quad (2A)$$

$$P^S = v^C\pi_{C|S} + v^S(1 - \pi_{C|S}) = v^S + \pi_{C|S}(v^C - v^S). \quad (2B)$$

With perfect quality measurement ( $u_{S|C} = u_{C|S} = \pi_{S|C} = \pi_{C|S} = 0$ ), prices would simply be processor valuations,  $P^C = v^C$  and  $P^S = v^S$ . Imperfect quality measurement causes an averaging of price as the uncertainty is taken into account. With no quality measurement at all ( $u_{S|C} = u_{C|S} = 0.5$ ,  $\pi_{C|S} = \lambda$ , and  $\pi_{S|C} = 1 - \lambda$ ), market prices converge to one average price over quality,  $P^C = P^S = \lambda v^C + (1 - \lambda)v^S$ .

Assume each producer in the market produces a uniform number of products (e.g. each cattle feedlot sells one pen of 100 cattle each marketing period) and that the proportion of producer  $i$ 's product that is choice is  $\lambda_i$ . This is the actual quality distribution of the producer's product. Using this value and the measurement error parameters, it can be determined that producer  $i$ 's product will grade  $\tilde{\lambda}_i = (1 - u_{S|C})\lambda_i + u_{C|S}(1 - \lambda_i)$ . With measurement error ( $u_{S|C} \neq 0$  and/or  $u_{C|S} \neq 0$ ),  $\lambda_i$  and  $\tilde{\lambda}_i$  will diverge. The average price the producer receives will be  $p_i = \tilde{\lambda}_i P^C + (1 - \tilde{\lambda}_i)P^S$ . As would be expected, prices are monotonic in quality, that is,  $\lambda_i > \lambda_j$  implies  $p_i > p_j$ . More interesting, though, is the distribution of prices and how this distribution changes as the level of quality measurement changes.

The market average price, regardless of the level of quality measurement, is the average valuation,  $\bar{p} = \tilde{\lambda} P^C + (1 - \tilde{\lambda})P^S = \lambda v^C + (1 - \lambda)v^S$ . Let the true valuation of a producer's products be  $v_i = \lambda_i v^C + (1 - \lambda_i)v^S$ . A producer with the market average quality,  $\lambda_i = \lambda$ , will receive the market average price, which is also the true valuation of that producer's output,  $p_i = \bar{p} = v_i$ . A producer with below average quality,  $\lambda_i < \lambda$ , receives a price below the market average but above the true valuation of their product,  $v_i \leq p_i \leq \bar{p}$ .

(where the first weak inequality is strict if there is imperfect quality measurement and the second weak inequality is strict if there is at least some quality measurement, however imperfect). A producer with above average quality,  $\lambda_i > \bar{\lambda}$ , receives a price above the market average but below the true valuation of their product,  $v_i \geq p_i \geq \bar{p}$ . In other words, the distribution of prices will have less variance than the distribution of true valuations, caused by the averaging effect of imperfect quality measurement. Because the model overall is zero-sum, the processors pay their valuation for the market distribution of product quality, but high quality producers receive a lower price and low quality producers receive a higher price than the valuation of their products.

As the level of quality measurement increases, prices move away from a point mass at  $\bar{p}$  and towards the actual distribution of  $v_i$ . The average price received by low quality producers declines while the average price received by high quality producers increases. In other words, the cross subsidisation of low quality producers by high quality producers diminishes as the level of quality measurement increases. The total payment by processors remains constant.

This model predicts that high quality producers will support (and expend resources to achieve), while low quality producers will oppose (and expend resources to prevent), increased levels of quality measurement. Processors should be largely indifferent to the level of quality measurement.<sup>2</sup> This pattern of support and opposition matches very closely recent changes in the level of quality measurement in the USA slaughter cattle market.

### 3. USA slaughter cattle spot market

The USA slaughter cattle market is the market between beef cattle feedlots that feed cattle out to slaughter weight and beef packing firms who buy the cattle and begin processing them into meat. In 2001, 36,576,000 head of cattle were traded, of which about 30 million were steers or heifers (ERS, 2002). Approximately 70 per cent of transactions take place in what the

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<sup>2</sup> The model developed assumes processing costs do not differ over quality. If they do, the indifference of processors may no longer hold. For the particular market under examination, these differences are small. Large differences like mature cows and bulls (versus slaughter heifers and steers) are largely handled at separate plants and are not a major portion of high quality measurement trades. The primary quality attributes examined in these high quality measurement transactions (quality grade and yield grade) are attempts to measure back fat thickness, marbling and so on, and while they do cause some differences for processors (higher levels of back fat require more trimming time and higher quality grade meat gets marketed to restaurants as opposed to supermarkets, perhaps causing differential marketing costs) these differences are not that economically significant relative to the price differentials being examined.

present paper will call the traditional spot market (GIPSA, 2002), which emerged after the decline of terminal markets in the 1960s and 1970s. The cattle are marketed weekly in pens of 50 to 200 head by show lists that contain entries for each market-ready pen. Packer procurement agents obtain the show lists and observe the cattle, eventually placing bids on the pens of cattle they wish to purchase. Feedlots sell to the highest bidder. See GIPSA (2000) for a detailed review of marketing practices in the slaughter cattle market.

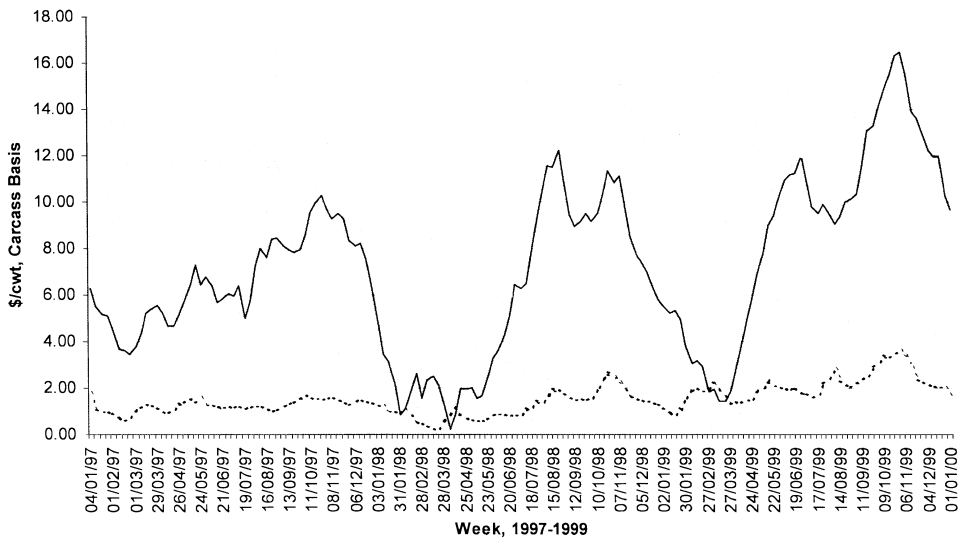
It has long been recognised that the cattle traded are of heterogeneous quality, and the USA Department of Agriculture (USDA) became involved in quality measurement in 1916. The USDA classification system focuses on the animal's age, sex, quality grade and yield grade. Quality grade is an attempt to predict palatability characteristics of the meat (juiciness, tenderness, flavour, etc.) and consists of the grades (from best to worst) prime, choice, select, standard, commercial, utility, cutter, and canner.<sup>3</sup> Yield grades range from one (best) to five (worst) and attempt to measure the pounds of meat obtained per pound of live animal (and subsequently, leanness).

The show lists generally contain some data on the background and feeder management of the pen of cattle which provides an indication of what the quality of the pen should be. Procurement agents then appraise the quality distribution (quality and yield grade) of the pen by conducting a quick visual appraisal. Agents attempt to gauge the age, health, and breeds of the animals in the pen (confirming the show list background information if provided) and their levels of fat deposit and muscle growth. The bid made will be an average of the packer's quality valuations weighted by the procurement agent's visual appraisal of the quality distribution. The visual appraisal is not very accurate and the result is very little price differentiation based on quality. The industry literature often calls the spot market an average price (over quality) market.

A striking contrast can be made between the choice-to-select price spread (premium paid to choice grade over select grade) paid to processors in their output market (the boxed-beef market) and an estimated choice-to-select price spread paid by processors in the slaughter cattle spot market. The choice to select boxed-beef price spread should serve as a proxy for the packer's input valuation spread ( $v^C - v^S$ ) because the marginal processing costs for choice and select cattle are very similar (see footnote 2). Unfortunately, no quality prices exist, per se, in the spot market because

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<sup>3</sup> In addition to the noise introduced by imperfect measurement of the specified traits, further noise is introduced by the fact that these traits only serve as proxies for the true quality characteristics valued by final consumers.



**Figure 1** Choice-select price spreads for boxed-beef and spot markets. — BB 700-850 spread, - - - - Smoothed spot spread. Source: USDA marketing reports, see data appendix for detailed description.

only average prices are realised for a pen of heterogeneous cattle. The *Weekly Weighted Average Slaughter Cattle Prices* report does provide sufficient data to estimate a choice and a select price spread. See the data appendix for a description of the procedure used, and Whitley (2000) for a more detailed discussion.<sup>4</sup>

Figure 1 presents these spreads weekly from 1997 to 1999, compiled from weekly USA Department of Agriculture marketing reports (see the data appendix for a detailed description). The boxed-beef spread (labelled BB 700–850 Spread) averaged \$7.16/cwt while the spot market spread (labelled Smoothed Spot Spread) averaged \$1.53/cwt, with a sample correlation coefficient of 0.79. The correlation of first differences is only 0.28. Although there is some differentiation based on quality, it can be seen that the industry characterisation of the spot market as an average price market is close to accurate.

<sup>4</sup> The data and Matlab code used to estimate the spread are available from the author. The final price spread series was smoothed for presentation (this did not effect any results quantitatively). The band pass filter weights for the filter  $y_t = b(L)x_t$ , set at 6 weeks are  $b_j = 2 * \sin(\pi_j/3)/\pi_j$ . These weights were approximated with the filter  $y_t = 0.1039x_{t-2} + 0.2077x_{t-1} + 0.3768x_t + 0.2077x_{t+1} + 0.1039x_{t+2}$ . For comparison on the quality premiums, see Williams *et al.* (1993) on cattle and Mullen (1995) on lambs for descriptions of the respective Australian markets and a more complete development of the methodology for estimating implicit quality price differentials (hedonic price regressions).



These data, along with market average quality (also available in weekly USDA marketing reports)<sup>5</sup>, can be used to estimate the measurement error parameters from the model in the previous section. As data are primarily available for the choice to select spread, it is convenient to express the model in terms of this spread. Subtracting equation 2B from equation 2A yields the following expression for the quality price spread:

$$\begin{aligned} P^C - P^S &= (v^C - v^S) - (\pi_{S|C} + \pi_{C|S})(v^C - v^S) \\ &= (v^C - v^S)(1 - \pi_{S|C} - \pi_{C|S}). \end{aligned} \quad (3)$$

This makes the suppression of the quality premium that results from imperfect quality measurement explicit. The shrinkage of the spread is simply proportional to the level of imputed assignment error,  $(1 - \pi_{S|C} - \pi_{C|S})$ . The observed shrinkage from \$7.16/cwt to \$1.53/cwt indicates a value in the range of 80 per cent for  $\pi_{S|C} + \pi_{C|S}$ .

Rewriting equation 3 in terms of the physical measurement error parameters yields:

$$\begin{aligned} P^C - P^S &= (v^C - v^S) \\ &\times \frac{(1 - u_{S|C} - u_{C|S})\lambda(1 - \lambda)}{(1 - u_{S|C} - u_{C|S} + 2u_{S|C}u_{C|S})\lambda(1 - \lambda) + u_{C|S}(1 - u_{C|S})(1 - \lambda)^2 + u_{S|C}(1 - u_{S|C})\lambda^2}. \end{aligned} \quad (4)$$

This is an equation in three endogenous variables ( $P^C - P^S$ ,  $v^C - v^S$ , and  $\lambda$ , the fraction of marketings grading choice or better) for which weekly data are available (or can be computed) and two exogenous technological parameters ( $u_{S|C}$  and  $u_{C|S}$ ) that are unknown. Defining

$$\begin{aligned} \varepsilon_t &= (P_t^C - P_t^S) - (v_t^C - v_t^S) \\ &\times \frac{(1 - u_{S|C} - u_{C|S})\lambda_t(1 - \lambda_t)}{(1 - u_{S|C} - u_{C|S} + 2u_{S|C}u_{C|S})\lambda_t(1 - \lambda_t) + u_{C|S}(1 - u_{C|S})(1 - \lambda_t)^2 + u_{S|C}(1 - u_{S|C})\lambda_t^2} \end{aligned}$$

the nonlinear least squares estimates of the parameters can be found by choosing the values of  $u_{S|C}$  and  $u_{C|S}$  that minimise  $\sum_{t=1}^T \varepsilon_t^2$ , where  $t$  denotes week and  $T = 157$  is the number of weeks in the three years from 1997 to 1999.<sup>6</sup>

The asymmetry of measurement error in the last two terms of the denominator ensures separate identification of the parameters as long as  $\lambda \neq 0.50$ . When the quality distribution is 50/50, the quality price spread

<sup>5</sup> True market average quality ( $\lambda$ ) is known because these data are taken from measurement that takes place in the processing plant, not visual appraisal in the spot market.

<sup>6</sup> The data and Matlab code are available from the author.

shrinks symmetrically in the two types of measurement error and they are not separately identifiable. Unfortunately, the average quality from 1997 to 1999 was 54.5 per cent and, after adjusting for the grid market selection (see below), the average was 52.8 per cent. When  $u_{S|C}$  and  $u_{C|S}$  were entered separately the estimation failed to converge so  $u = u_{S|C} = u_{C|S}$  was imposed.

The nonlinear least squares estimate of  $u$  is 40 per cent (the estimate is 0.4020 and its standard error is 0.0293). Computing  $\pi_{C|S}$  and  $\pi_{S|C}$  for each market week and taking the average gave estimates for these of 42.98 per cent and 37.55 per cent, respectively. This implies that, on average, from 1997 to 1999 an animal that visually appraised choice had a 38 per cent chance of actually being select, and an animal that visually appraised select had a 43 per cent chance of actually being choice. If packers value select animals at \$100/cwt and choice animals at \$107/cwt, the spot market price for a choice (visually appraised) animal would be \$104.34/cwt and the spot market price for a select animal would be \$103.01/cwt (with a \$1.33/cwt choice premium). Roughly speaking, the \$2.66/cwt lost on animals that grade choice is the reason high quality producers desire higher levels of quality measurement and the \$3.01/cwt gained on animals that grade select is the reason low quality producers oppose higher levels of quality measurement.

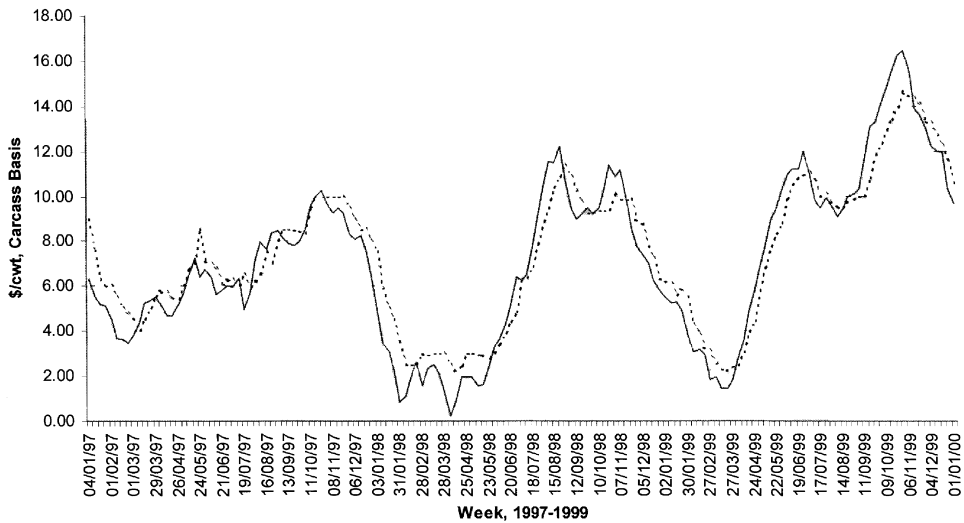
#### 4. Grid pricing in the USA slaughter cattle market

The last decade has seen the emergence of an alternative marketing channel in the USA slaughter cattle market that involves a much higher level of quality measurement. Ward *et al.* (1996) and Ward *et al.* (1999) provide detailed examinations of USA beef cattle marketing (and changes in marketing arrangements) during this time period. The new marketing channel is called grid pricing and has grown throughout the last decade to reach its current level of about 30 per cent of all market transactions.<sup>7</sup> At the transaction date, processors offer a schedule (grid) of premiums and discounts for quality traits over a base price (or formula to determine a base price). The animals are shipped to the packer and slaughtered. Prior to fabrication (the processing of the carcass into individual primal or retail cuts), the carcass is graded and the results recorded.<sup>8</sup> Producers are paid within three to four days of delivery at the plant.

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<sup>7</sup> This is called “over-the-hooks” marketing in Australia.

<sup>8</sup> The grading can be done solely by a USDA grader or by a combination of a USDA grader (measuring quality and yield grade) and a packer employee (measuring brand specification eligibility, additional measurements, etc.). The market is currently experimenting with additional measurements and measurement technologies, including digital cameras and ultrasound equipment.



**Figure 2** Choice-select price spreads for boxed-beef and grid priced markets. - - - - Grid spread, — BB 700-850 spread. Source: USDA marketing reports, see data appendix for detailed description.

Figure 2 illustrates the grid choice-to-select price spread along with the previously discussed boxed-beef spread. Not only has the grid spread followed the boxed-beef spread closely (their correlation coefficient is 0.96), but the mean of the grid spread is \$7.40/cwt compared with \$7.16/cwt for the boxed-beef spread.<sup>9</sup> Although the base price adjusts when moving from the spot market to the grid market, the change from a \$1.53/cwt to a \$7.16/cwt choice premium is quite large (cattle prices average \$103/cwt and the feeder's margin after feeder calf and feed purchases averages \$6/cwt to \$7/cwt – see Taylor, 1994, for a breakdown of feeder finances).

The emergence of grid pricing has been accompanied by fierce opposition from producers (feedlots) claiming that it is an instrument for the exercise of monopsony power by processors who are highly concentrated, with a national average four-firm concentration ratio of over 80 per cent for steer and heifer slaughter (GIPSA, 2001). Although market power

<sup>9</sup> An alternative to the imperfect quality measurement explanation for the quality price spread suppression in the spot market is that packers have used market power to create artificial scarcity along the quality margin, thereby deflating the quality premium. The higher average premium in the grid market than the packers' output market is suggestive, however, that there is no such suppression in the grid market which, in turn, is suggestive that there is no suppression in the spot market since a price discriminator still suppresses both markets.

may be a serious concern in the market, the pattern of support and opposition to grid pricing implies that more is going on. Agricultural economists have long been arguing in favour of value-based marketing in livestock markets (see Purcell, 1989), but processors have been reluctant to change procurement practices. The actual pressure to begin grid pricing came from producers.

The first significant grid pricing arrangement was initiated by National Farms (a producer with 274,000 head capacity) in the late 1980s and was followed quickly by Cactus Feeders (another producer with 480,000 head capacity). Both of these are large producers but subsequent entry has included some of the smallest producers in the market. The Decatur Feed Alliance was an early entrant (1994) and involves the Decatur County Feedyard with a capacity of 38,000 head. One group of producers (US Premium Beef) created a marketing cooperative and bought a large share of the fourth largest processing firm (Farmland National Packing) in order to establish a value based marketing scheme and capture a share of the excess return they thought would be generated. This group includes producers that range in size from 200 head to 100,000 head.

This pattern of support and opposition is seen in many other agricultural markets that are experiencing increases in the level of quality measurement. The increases are largely producer-initiated and it is other groups of producers that are opposed. Pure monopsony price suppression is not compatible with this pattern. Quality cross-subsidisation and multimarket price discrimination are both compatible. If a more price responsive (elastic) group of producers knew that differentiating themselves from the rest of the producers would result in a reduction in the monopsony price suppression they were experiencing, then they would favour an alternative marketing channel that would differentiate them from the other producers. The present paper cannot definitively differentiate these two possibilities. However, the following two sections present some suggestive evidence that quality differentials alone are able to explain price differentials between the two markets.

## **5. Quality selection and market power**

Ward (1987) and Love and Burton (1999) offer theoretical models of how multimarket price discrimination might be implemented by packing firms. Applying their argument to grid pricing would mean that quality measurement was serving as a screening device to separate producers into two groups (high quality/high elasticity of supply producers and low quality/low elasticity of supply producers). Several empirical studies have attempted to measure the relationship between the frequency of non-spot market trades

(what fraction of total trades are grid-priced or contracted in some other way) and the spot market price. Elam (1992), Schroeder *et al.* (1993), Ward *et al.* (1996), Hayenga and O'Brien (1992), and Schroeter and Azzam (1999) all found some evidence of a negative relationship (the higher the fraction of total transactions that take place out of the spot market, the lower the spot market cattle price). Although varied, the results imply that with approximately 20 per cent of transactions taking place out of the spot market, the likely decline in the spot market price is in the neighbourhood \$0.30 to \$0.40/cwt. These results were interpreted as providing evidence in support of the price discrimination argument.

Of course, producers selling cattle under a grid pricing scheme faced an average choice to select quality premium of \$7.40/cwt while spot market cattle were paid a \$1.53/cwt quality premium from 1997 to 1999. Presumably high quality producers self-select into the high quality measurement marketing channel, leaving the average quality in the spot market lower and causing the average price in the spot market to decline. The relevant question is thus whether or not quality selection alone can explain the observed price declines in the spot market. Multimarket price discrimination would imply a differential larger than quality differentials alone can explain.

There is significant anecdotal evidence that quality is not randomly distributed across transaction types. In 1999, of the 1092 pens National Farms sold, 882 (81.4 per cent) graded higher (fraction of the pen grading choice or prime) than the average of the plant they were sold to for that market week. Over all pens for the year, National Farms averaged 13.7 per cent higher quality than the plants sold to. US Premium Beef averaged 67.3 per cent choice or prime and 61.3 per cent Yield Grade 1 and 2 marketings for 1999. The national average for 1999 was 56.0 per cent choice or prime and 51.2 per cent Yield Grade 1 and 2. These higher quality cattle received higher prices. In 1999, National Farms averaged (over pens) \$1.32/cwt in quality premiums. US Premium Beef averaged \$14.85/head in premiums (\$1.98/cwt for a 750 pound carcass).<sup>10</sup>

Unfortunately, systematic (aggregate) data are not available on the quality of marketings by marketing channel or the prices received by marketing channel. Weekly data are available on the overall distribution of quality and the number of grid transactions can be approximated weekly. The remainder of this section presents some summary statistics from this data and the next section develops a simple model of quality supply to compute rough

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<sup>10</sup> US Premium Beef data are from their publication *USPB Update*. The National Farms statistics are from raw data provided by Mr Glenn Poe.

**Table 1** Summary statistics of data and constructed variables

| Variable                               | Mean         | Median | Std. Dev. | Minimum | Maximum |
|--|--------------|--------|-----------|---------|---------|
| Non-spot trades ( $\gamma$ )           | 18.18%       | 18.32  | 4.28      | 8.37    | 29.95   |
| Prime marketings                       | 2.16%        | 2.04   | 0.53      | 0.97    | 3.79    |
| Choice marketings                      | 52.47%       | 51.95  | 2.83      | 46.49   | 58.91   |
| Select marketings                      | 36.07%       | 36.90  | 2.90      | 28.74   | 41.16   |
| Y.G. 1 marketings                      | 10.94%       | 10.72  | 1.20      | 8.82    | 14.56   |
| Y.G. 2 marketings                      | 43.34%       | 43.49  | 1.47      | 40.08   | 47.17   |
| Y.G. 3 marketings                      | 33.55%       | 33.91  | 2.51      | 27.47   | 38.92   |
| Y.G. 4 marketings                      | 1.19%        | 1.19   | 0.25      | 0.70    | 1.70    |
| Y.G. 5 marketings                      | 0.09%        | 0.09   | 0.02      | 0.05    | 0.16    |
| Bull marketings                        | 1.14%        | 1.14   | 0.12      | 0.74    | 1.44    |
| Quality premium:<br>Prime to choice    | \$6.08/cwt   | 6.50   | 0.69      | 3.83    | 6.50    |
| Quality premium:<br>Choice to select   | \$7.45/cwt   | 7.50   | 3.20      | 2.21    | 14.58   |
| Quality premium:<br>Select to standard | \$10.01/cwt  | 9.54   | 1.78      | 6.39    | 14.83   |
| Quality premium:<br>Y.G. 1 to Y.G. 2   | \$0.68/cwt   | 0.50   | 0.21      | 0.50    | 1.13    |
| Quality premium:<br>Y.G. 2 to Y.G. 3   | \$1.31/cwt   | 1.44   | 0.21      | 1.00    | 1.50    |
| Quality premium:<br>Y.G. 3 to Y.G. 4   | \$14.90/cwt  | 14.50  | 1.29      | 12.00   | 18.13   |
| Quality premium:<br>Y.G. 4 to Y.G. 5   | \$4.97/cwt   | 5.00   | 0.11      | 4.50    | 5.00    |
| Quality premium:<br>Bulls              | \$-28.12/cwt | -28.00 | 2.77      | -36.75  | -25.20  |
| Cattle price level                     | \$103.00/cwt | 103.49 | 4.99      | 90.99   | 112.67  |
| Corn price                             | \$2.25/bu.   | 2.33   | 0.36      | 1.67    | 2.89    |

Data from USDA Marketing Reports (see data appendix for detailed description).

estimates of the level of quality selection and expected price differential between marketing channels.

Weekly data on the (actual) quality distribution of total marketings over nine traits (prime, choice, select, yield grade one to yield grade five, bulls) are available from the USDA report *National Steer and Heifer Estimated Grading Percent Report*, and the *Breakdown of Reported Feedlot Volume Report* provides the best estimate available of non-spot market trades by week. Table 1 provides summary statistics of these data. If the fraction of week  $t$ 's marketings of a particular quality are denoted  $\lambda_t$  (e.g. the fraction of marketings that grade choice) and the fraction of the week's marketings that were non-spot trades are denoted  $\gamma_t$ , then the regression  $\lambda_t = \alpha_0 + \alpha_1\gamma_t + \alpha_2x_t + \varepsilon_t$ , where  $x_t$  is a vector of control variables and  $\varepsilon_t$  is a random error term, yields the summary statistic  $\alpha_1 = E(\lambda_t|\gamma_t = 1, x_t) - E(\lambda_t|\gamma_t = 0, x_t)$ , the average differential in quality between the two marketing channels (e.g. if  $\alpha_1 = 15$  and spot market cattle

**Table 2** Summary statistics on quality differentials

|                                     | Trait           |                  |                  |                  |                  |                  |                  |                  |                 |
|-------------------------------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-----------------|
|                                     | Prime           | Choice           | Select           | Y.G. 1           | Y.G. 2           | Y.G. 3           | Y.G. 4           | Y.G. 5           | Bulls           |
| Quality differential ( $\alpha_1$ ) | 2.03<br>(1.21)  | 13.29*<br>(4.44) | -1.75<br>(4.95)  | -9.26*<br>(2.44) | 4.02<br>(3.63)   | 18.96*<br>(3.72) | 0.33<br>(0.39)   | -0.02<br>(0.04)  | -0.01<br>(0.27) |
| Base price ( $\alpha_{21}$ )        | -0.01<br>(0.01) | -0.04<br>(0.03)  | 0.10*<br>(0.03)  | 0.06*<br>(0.02)  | 0.14*<br>(0.03)  | 0.00<br>(0.02)   | -0.00<br>(0.00)  | -0.00*<br>(0.00) | 0.00<br>(0.00)  |
| Quality premium ( $\alpha_{22}$ )   | 0.04<br>(0.10)  | -0.45*<br>(0.07) | -0.48*<br>(0.12) | -0.00<br>(0.52)  | 4.17*<br>(1.45)  | 1.16*<br>(0.18)  | -0.36*<br>(0.11) | -0.06*<br>(0.01) | 0.02*<br>(0.00) |
| Corn price ( $\alpha_{23}$ )        | -0.37<br>(0.20) | -0.58<br>(0.59)  | -1.51*<br>(0.66) | 0.51<br>(0.34)   | -2.91*<br>(0.98) | -0.59<br>(0.55)  | -0.50*<br>(0.04) | -0.04*<br>(0.00) | 0.24*<br>(0.05) |
| Constant ( $\alpha_0$ )             | 3.72*<br>(1.47) | 58.71*<br>(3.37) | 35.54*<br>(3.73) | 4.85*<br>(1.85)  | 28.34*<br>(3.21) | 13.32*<br>(4.91) | 4.27*<br>(0.56)  | 0.60*<br>(0.06)  | 1.01*<br>(0.22) |
| Number of observations              | 157             | 157              | 157              | 157              | 157              | 157              | 157              | 157              | 157             |
| $R^2$                               | 0.39            | 0.70             | 0.65             | 0.51             | 0.25             | 0.72             | 0.70             | 0.57             | 0.39            |

Standard errors in parentheses, \* denotes significance at 5% level.

Note: Each column estimated separately by ordinary least squares. Data from USDA marketing reports.

were 50 per cent choice, then 65 per cent of grid price cattle were choice).<sup>11,12</sup> Table 2 presents these summary statistics.<sup>13</sup> Control variables used are base cattle price, quality premium for that trait, corn price, and three seasonal dummy variables. These variables were obtained from weekly USDA marketing reports (see data appendix for specific reports). Table 1 provides their summary statistics.

There is a statistically significant difference in average quality across marketing channels for choice quality grade and yield grades one and three (prime is significant at a 10 per cent level).<sup>14</sup> Fitted values from the estimated model (with appropriate values for  $\gamma_t$ ) can be used to estimate the average quality over the three years for each marketing channel. The results imply that spot market cattle averaged 50.05 per cent choice, 12.62 per cent yield grade 1, and 30.11 per cent yield grade 3 while non-spot market cattle averaged 63.34 per cent choice, 3.36 per cent yield grade 1,<sup>15</sup> and 49.07 per cent yield grade 3. During these three years, the average premiums were \$7.45 for choice over select, \$0.68 for yield grade 1 over 2, and \$14.90 for yield grade 3 over 4. Unfortunately, these summary statistics cannot be used to show causation, they simply indicate the degree to which high levels of spot market transactions are correlated with low market average quality. To show causation, the supply of quality must be explicitly estimated.

## 6. Quality supply and price differentials

This section develops a simple model of quality supply and uses it to estimate the level of quality selection across marketing channels and the associated

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<sup>11</sup>  $E(\lambda_t|\gamma_t = 1, x)$  is the average quality when  $\gamma_t = 1$  (all cattle are traded in non-spot market transactions) and  $E(\lambda_t|\gamma_t = 0, x)$  is the average quality when  $\gamma_t = 0$  (all cattle are traded in the spot market). The difference of these would be the average quality difference between the marketing channels.

<sup>12</sup> Note that  $\lambda_t$  (fraction of marketings of a particular quality) was multiplied by 100 per cent in the empirical work.

<sup>13</sup> A regression was estimated for each of the nine quality traits. There are some cross equation restrictions available from the fact that all yield grades and all quality grades cannot sum to greater than 100 per cent. Unfortunately these restrictions cannot practically be imposed because of the control variables.

<sup>14</sup> Note that although yield grades one to five are exhaustive, it is not inconsistent for the sum of the differences to be positive since all spot market cattle are not graded.

<sup>15</sup> Grid priced cattle having a lower fraction grading yield grade one is actually not surprising given that over the three years examined quality grade premiums were dramatically larger than yield grade premiums and there is a trade off in management for the two (feeding cattle longer raises quality grade but can eventually begin to reduce yield grade).



price differential. Perhaps the simplest model of quality supply is to specify a supply equation for each grade of quality (i.e. since data are available on nine different grades of quality, specify nine separate supply equations). To separate the quantity decision (which is not of interest) from the quality decision (which is of interest), express the quality supplies as fractions of total marketings. Thus, the supply of a particular grade of quality is  $\lambda = \lambda^*(p, S, p_C)$  where  $\lambda$  is the fraction of total marketings of that grade of quality (e.g. fraction of total marketings that are yield grade one),  $p$  is the base cattle price,  $S$  is the price premium for that grade of quality (e.g. if the base price is for select animals and the grade of quality under examination is choice, then the price premium is \$7.45/cwt from table 1), and  $p_C$  is the price of corn.<sup>16</sup>

This model abstracts from at least two potentially important aspects of the actual supply decision. First, the supply of each grade of quality is not a separate decision. For a given quantity, the choice is between the grades of quality. Unfortunately, these cross equation restrictions greatly reduce the tractability of the estimations and it was decided to leave them for future research when more (and higher quality) data have become available. Second, one of the primary concerns in beef quantity supply estimation is the dynamic nature of supply. The actual feedlot problem generally involves a corner solution over feed quantity (feed the animals as much as they will eat) and the relevant choice variable is the optimal stopping time.<sup>17</sup> This is relevant for quality choice as well. Feeding the animals longer will ensure a higher fraction grade choice and prime, but will lower the yield grade. A limited attempt was made to deal with this in the specifications below by using future prices and simple models of price expectation formation. The results were not affected by these extensions and they will not be discussed further.

There are currently two primary marketing channels in the slaughter cattle market (the spot channel and the grid priced channel). Assume that producers are homogenous within marketing channels so that the entire quality supply within the channel can be expressed with the above supply equation. Suppose further that the supply functions differ across marketing

<sup>16</sup> This supply equation can be derived from the feedlot's profit maximisation problem. The feedlot's profit equation (when only the base quality and one other grade are being considered) is  $\pi = (p + \lambda S)q - c(q, \lambda; p_C)$  where  $q$  (quantity) and  $\lambda$  are the choice variables,  $p$ ,  $S$ , and  $p_C$  are parameters to the feedlot, and  $c(\bullet, \bullet; p_C)$  is the feedlot's cost function.

<sup>17</sup> The primary development of the dynamic nature of fed cattle supply is from Yver (1971) and Jarvis (1974). See also Rosen (1987) and Rosen *et al.* (1994) for more recent developments. There is some evidence for this in table 2 where base price enters negatively in several estimations (although only one negative result is significant) and quality premium enters negatively (and significantly) for choice, select, yield grade four, and yield grade five.

channels because of managerial talent or some other factor which determines the producer's choice of marketing channel. There are now two supply equations for a particular grade of quality, the spot market supply (SM) and the grid market supply (GM):

$$\lambda^{SM} = \lambda^{SM}(p, S, p_C) \quad (5A)$$

$$\lambda^{GM} = \lambda^{GM}(p, S, p_C). \quad (5B)$$

Producers actually face different quality premiums and base price levels in the two marketing channels. Unfortunately, base price is only available from spot market trades and quality price premiums are only available from grid priced trades. Out of necessity, assume that prices and price premiums across marketing channels are only multiplicative shifts of each other and that these shifts can be combined with parameter values.

If  $\gamma$  is the fraction of total marketings that are grid-priced, then the market average quality is  $\lambda = \gamma\lambda^{GM} + (1-\gamma)\lambda^{SM} = \lambda^{SM} + \gamma(\lambda^{GM} - \lambda^{SM})$ . With a functional form for  $\lambda^{SM}$  and  $\lambda^{GM}$ , this equation can be estimated. Linear, quadratic, and semi-log specifications were all estimated and the results were similar, for simplicity the linear specification will be developed and presented here. The two marketing channels' supply equations are thus:

$$\lambda^{SM} = \lambda^{SM}(p, S, p_C) = \beta_0^{SM} + \beta_1^{SM}p + \beta_2^{SM}S + \beta_3^{SM}p_C \quad (6A)$$

$$\lambda^{GM} = \lambda^{GM}(p, S, p_C) = \beta_0^{GM} + \beta_1^{GM}p + \beta_2^{GM}S + \beta_3^{GM}p_C. \quad (6B)$$

Filling these into the market average quality equation yields the market average quality supply for a particular grade of quality:

$$\begin{aligned} \lambda &= \lambda^{SM} + \gamma(\lambda^{GM} - \lambda^{SM}) = \beta_0^{SM} + \beta_1^{SM}p + \beta_2^{SM}S + \beta_3^{SM}p_C \\ &\quad + \gamma(\beta_0^{GM} + \beta_1^{GM}p + \beta_2^{GM}S + \beta_3^{GM}p_C - \beta_0^{SM} - \beta_1^{SM}p - \beta_2^{SM}S - \beta_3^{SM}p_C) \\ &= \beta_0^{SM} + \beta_1^{SM}p + \beta_2^{SM}S + \beta_3^{SM}p_C + (\beta_0^{GM} - \beta_0^{SM})\gamma + (\beta_1^{GM} - \beta_1^{SM})\gamma p \\ &\quad + (\beta_2^{GM} - \beta_2^{SM})\gamma S + (\beta_3^{GM} - \beta_3^{SM})\gamma p_C \\ &= \beta_0^{SM} + \beta_1^{SM}p + \beta_2^{SM}S + \beta_3^{SM}p_C + \beta_4\gamma + \beta_5\gamma p + \beta_6\gamma S + \beta_7\gamma p_C. \end{aligned} \quad (7)$$

Three seasonal dummies were also included in each regression.

With data on nine grades of quality, there are nine separate equations of this form ( $p$ ,  $p_C$ , and  $\gamma$  are the same for each of the nine equations while  $\lambda$  and  $S$  are specific to the grade of quality being examined). These equations can be estimated with the 157 weekly observations from 1997 to 1999 used in the previous section and described in the data appendix. From the estimated equations the fitted values:

$$\lambda^{GM} - \lambda^{SM} = \beta_4 + \beta_5 p + \beta_6 S + \beta_7 p_C \quad (8)$$

yield the quality differences between the two marketing channels. More specifically, if the fitted value for the choice quality grade equation were estimated to be 12, then that would imply that if the spot market trades average 50 per cent choice then the grid market trades averaged 62 per cent choice.

Table 3 presents these fitted values for each of the nine quality traits in the first column labelled model 1 (the full estimation results with all parameter estimates are available from the author). As can be seen, there is a statistically significant difference (i.e. the fitted value is statistically significant) for choice, Yield Grade 1, and Yield Grade 3. Grid-priced cattle average 12.17 percentage points more grading choice than spot market cattle (e.g. if 50 per cent of spot market cattle graded choice, then 62.17 per cent of grid price cattle graded choice), similarly grid price cattle average 9.31 percentage points less grading Yield Grade 1 than spot market cattle and 19.89 percentage points more grading Yield Grade 3 than spot market cattle.

These results can be used to infer average price differences across marketing channels (because direct data are not available on this). If  $\bar{p}^{SM}$  is the average price in the spot market channel and  $\bar{p}^{GM}$  is the average price in the grid market channel, then for one grade of quality the price differential is computed by  $\bar{p}^{GM} - \bar{p}^{SM} = S(\lambda^{GM} - \lambda^{SM})$ . Computing this for each grade of quality and adding the price differences yields the total price difference

**Table 3** Quality selection across marketing channel and price premiums

| Estimate                                   | Model         |               |               |               |
|--|---------------|---------------|---------------|---------------|
|  | 1             | 2             | 3             | 4             |
| Prime                                      | 0.15 (0.97)   | 0.10 (0.96)   | -0.06 (1.02)  | -0.49 (1.07)  |
| Choice                                     | 12.17* (4.50) | 11.48* (4.47) | 12.20* (4.79) | 10.71* (4.95) |
| Select                                     | -3.44 (5.16)  | -4.03 (5.04)  | -1.12 (5.48)  | -6.95 (6.03)  |
| Y.G. 1                                     | -9.31* (2.58) | -9.35* (2.57) | -7.61* (2.83) | -7.64* (2.92) |
| Y.G. 2                                     | 3.78 (3.74)   | 3.63 (3.96)   | 5.30 (4.04)   | 4.60 (4.38)   |
| Y.G. 3                                     | 19.89* (4.30) | 20.79* (4.20) | 15.75* (4.87) | 18.48* (4.96) |
| Y.G. 4                                     | -0.09 (0.36)  | -0.01 (0.35)  | -0.35 (0.39)  | 0.11 (0.42)   |
| Y.G. 5                                     | -0.04 (0.05)  | -0.02 (0.05)  | -0.08 (0.05)  | -0.06 (0.05)  |
| Bulls                                      | -0.01 (0.28)  | -0.03 (0.27)  | 0.05 (0.29)   | 0.01 (0.29)   |
| Price differential:<br>Grid to spot        | 3.39* (0.11)  | 3.34* (0.09)  | 3.22* (0.14)  | 2.65* (0.14)  |
| Price differential:<br>Market ave. to spot | 0.62* (0.02)  | 0.61* (0.02)  | 0.61* (0.03)  | 0.47* (0.03)  |

Standard errors in parentheses, \* denotes significance at 5% level.

Note: Each quality trait cell represents a fitted value from a separate regression. The models estimated were: 1) OLS; 2) OLS with base price excluded; 3) 2SLS with pig and poultry wholesale prices as instruments for base price; 4) 2SLS with nearby live cattle futures contract price as an instrument for base price. Data from USDA marketing reports.

between grid and spot market cattle.<sup>18</sup> Similarly, the overall market average price is  $\bar{p} = \gamma\bar{p}^{GM} + (1 - \gamma)\bar{p}^{SM}$  and the difference between the overall market average price and the average price in the spot market is given by  $\bar{p} - \bar{p}^{SM} = \gamma(\bar{p}^{GM} - \bar{p}^{SM})$ . This last expression is particularly interesting because it represents the decline in the average price for spot market cattle that results from the presence of the grid pricing channel.

Using all nine quality traits<sup>19</sup> the estimates in table 3 indicate that there was a statistically significant average price difference between grid and spot market cattle of \$3.39/cwt and a price difference of \$0.62/cwt between the overall market average price and the spot market price.<sup>20</sup> The second estimate is the relevant estimate to compare with the empirical results from past studies reported above. This is the price increase that would occur in the spot market if all cattle were sold in the spot market. In other words, this is the decline that occurs in the spot market price when high quality cattle move into the grid priced marketing channel. The quality price differential estimated here is actually larger than the estimates reported above from the market power literature (the average result in that literature is about \$0.30 to 0.40/cwt). This may arise from the fact that grid pricing has been increasing in use and composed a smaller fraction of total market transactions during the time periods of the earlier studies. Overall, the results are suggestive that quality differentials alone are able to explain the price divergences between marketing channels and the negative relationship between the level of non-spot market transactions and spot market price found in the previous studies that were attributed to market power. The previous studies found a price decrease in the spot market of \$0.30 to \$0.40/cwt from the presence of non-spot market transactions, the present study has found that the quality selection that should arise from the presence of a grid pricing channel alone predicts a \$0.62/cwt price difference.

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<sup>18</sup> When all quality traits are examined, the computation becomes more complicated because not all increases in a particular grade of quality come from the next lowest grade of quality. In the estimations reported it is assumed that increases in prime and choice quality grade come from animals that would have graded select, the increase in yield grade two and part of the increase in yield grade three come from the decline in yield grade one, and the remaining increase in yield grade three comes from yield grade four.

<sup>19</sup> Because estimating fitted values is the object of the exercise, it is appropriate to use all estimates taking into account their degree of uncertainty (standard errors). Even so, using only the statistically significant quality differentials yields virtually identical results that are even more statistically significant.

<sup>20</sup> The small standard errors reflect that the reported estimates are an average of the 157 point estimates (one for each week). Of the 157 point estimates, the average standard error for the grid to spot price differential is 1.36 and for the market to spot price differential is 0.25. Of the 157 weeks, 119 have statistically significant (at 5 per cent) price differentials.

The above supply estimations have implicitly assumed exogeneity of the control variables. This is probably reasonable for corn price ( $p_C$ ), but may be less so for cattle base price ( $p$ ), quality premium ( $S$ ), and fraction of non-spot transactions ( $\gamma$ ). Since marginal fabrication costs do not vary widely over carcasses of varying quality, it will be assumed in the present paper that quality price premiums ( $S$ ) largely pass through the packing plant and are sufficiently exogenous to be used without concern.<sup>21</sup> In addition, because feedlots participating in grid pricing schemes generally sell exclusively under the scheme and do not move back and forth between marketing channels, the bulk of weekly variation in non-spot market transactions simply comes from the quantity decisions of sellers in the two marketing channels leaving this variable ( $\gamma$ ) largely exogenous from a weekly perspective.

However, none of these arguments are reasonable for the base price level. To control for this potential endogeneity problem, several alternative estimations were performed. Model 2 in table 3 presents the results when base price is simply excluded from the regressions. Model 3 presents results where pork and chicken wholesale prices (demand shifters) and all exogenous variables are used as instruments for price level, and model 4 uses the nearby live cattle futures contract price and all exogenous variables as instruments for price level. As can be seen, the results are very robust to these extensions.

## 7. Conclusion

The rise in quality measurement seen in many agricultural markets in recent years has been met by opposition from some groups of producers and has been openly promoted by others. This calls into question the standard market power arguments often used by opponents of the marketing changes. The present paper has presented a simple model of imperfect quality measurement that is compatible with this pattern of opposition and support and, when estimated in the context of the USA slaughter cattle market, implies price effects large enough to be driving observed actions. Empirical estimates demonstrate that self-selection of high quality cattle out of the spot market is large enough to explain price declines that were attributed to monopsony price suppression in previous papers.

The model in the first two sections of this paper has followed the literature and assumed that quality supply is perfectly inelastic with respect to price (base price level and quality premium). An exogenous, perfectly inelastically supplied factor like managerial talent or weather determined  $\lambda_i$  and there was

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<sup>21</sup> Excluding price premiums from the estimations slightly increases the estimated price differentials.

no endogenous response to the level of quality premiums. The later sections allowed quality supply choice to be endogenous and estimated a simple specification for quality supply. Results were suggestive that there is selection of higher quality cattle out of the spot market into the grid priced marketing channel. This selection may have led to a price decline in the spot market of more than \$0.60/cwt.

The last few years has seen a dramatic increase in the collection and quality of data on product quality. Most of the data used in the present paper began to be collected in 1997. As the quantity and quality of data improve, more rigorous and thorough empirical work will be possible.

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## Appendix

The majority of the data used in the present paper are from USDA market news reports and cover the 157 weeks from 1997 to 1999. Table 1 provides summary statistics for selected variables. The *Estimated Composite of Boxed Beef Cut-Out Values Report* constructs a daily estimate of the value of a fabricated beef carcass by adding together the prices of the individual cuts of meat that comprise the carcass. Choice and select prices are computed for carcasses that weigh 550–700 pounds and for carcasses that weigh 700–850 pounds. These prices, less marginal processing cost, are the packers' valuation for slaughter cattle. As fabrication costs are roughly the same for choice and select carcasses, the boxed-beef choice-select spread can be used as a proxy for the choice-select valuation spread (see footnote two). The *National Premiums and Discounts for Slaughter Steers and Heifers Report* collects at the beginning of the week by phone, surveying the high, low, and average premium (or discount) for a variety of quality traits offered by packing plants in grid priced procurement each week. The report was started in 1997 and did not include an average for the first two years, for these years a simple average of the high and low was used.

The *Weekly Weighted Average Slaughter Cattle Prices Reports* were used to impute the spot market choice to select spread. They provide pen prices for five geographical regions broken down into five quality categories. The regions are Texas/Oklahoma, Kansas, Nebraska, Colorado, and Iowa/Southern Minnesota. These regions accounted for 73 per cent of total federally inspected USA slaughter from July to December, 1999. The quality categories are pens that visually appraise 0 per cent–20 per cent choice, 20 per cent–35 per cent choice, 35 per cent–65 per cent choice, 65 per cent–80 per cent choice, and 80 per cent–100 per cent choice. Prices are further broken down by sex and pricing basis (live weight or carcass weight), yielding four replications of the geographical and quality categories. For a given market week, then, if the average quality in a category is assumed to be the categories midpoint (i.e. the average quality of the 65 per cent–80 per cent range is 72.5 per cent choice) there are 100 potential equations to solve for the two quality prices (regions do not report transactions in all categories and most weeks averaged about 40 price/quality pairs). Using least squares criteria and weighting by the number of head traded in each category, estimates were



made for the choice and select prices for each week. A 62.5 per cent dressing per cent (to calibrate carcass and live weight pricing) and level shift dummies for region and sex were used. Nine weeks (primarily Christmas and other holiday weeks) had too few observations to estimate and linear interpolation was used to estimate their values.

The *National Steer and Heifer Estimated Grading Percent Report* provides weekly overall quality breakdowns by geographic regions. The spot market price data includes Colorado, Iowa, Kansas, Nebraska, Oklahoma, Texas, and Southern Minnesota. The quality report includes these states (except Southern Minnesota) and Arkansas, Louisiana, Missouri, New Mexico, Montana, North Dakota, South Dakota, Utah, and Wyoming. From June to December 1999, these additional states accounted for less than 4 per cent of total federally inspected slaughter for the whole region. This mismatch is ignored. The quality report provides overall market average quality, the relevant quality for the estimation of Hennessy's model is spot market average quality. This was estimated by correcting for the quality selection found in the third section of the main text.

The estimation of the level of quality selection uses the above variables, corn prices, and the fraction of grid marketings. Corn prices for the regions were collected from individual USDA market news offices and state Departments of Agriculture. The most difficult to obtain variable is the level of captive versus spot marketings. The *Breakdown of Reported Feedlot Volume Report* provides the best weekly estimate available of captive supply marketings. The report provides data for four regions, Texas/Oklahoma, Kansas, Colorado, and Nebraska/Wyoming. For these regions, the report lists cash sales and additional movement, which includes: (i) cattle that are fed by or for packers; (ii) contract or formula agreements; (iii) cattle financed by packers and slaughtered by the same packer; and (iv) cattle committed to packers with the price non-negotiated prior to change in ownership. The fraction of grid marketings is computed by dividing the additional movement in a week by the total slaughter (from the *National Steer and Heifer Estimated Grading Percent Report*) for the week.