# The Political Economy of Quality Measurement: A Case Study of the U.S. Slaughter Cattle Market

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## ABSTRACT

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. This 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 U.S. slaughter cattle market. Estimates of the economic impact on producers of measuring quality more accurately are found to be similar in size to previous estimates of market power price suppression in the market.

**JEL Classification:** Q11, Q13

**Key Words:** quality, captive supplies, cattle, asymmetric information

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The level of quality measurement in many (if not most) agricultural markets has increased during the last decade. Examples include measurements of staple length and fibre diameter in wool markets, large increases in quality differentials in wine grapes (measurement is largely done through repeat transactions, but near infra red spectroscopy and other technological advances are promoting measurements at the transaction date as well), meat marbling and yield in slaughter livestock markets (Meat Standards Australia, for example), and many more. The notion of agricultural goods being homogeneous commodities is being rejected as quality differentials begin to cause large price differentials for what has historically been considered the same product. 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 long period of being largely ignored. As income levels (exogenously) rise, the positive income elasticity of quality demand implies consumers will become more discriminating in their food purchases. As national agricultural markets increase in size and national markets converge with markets of other countries to produce global markets, opportunities for product specialization 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 been met by 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 high quality measurement marketing alternatives. In addition, processors themselves (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.

This paper examines the distributional effects of increased quality measurement 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 U.S. slaughter cattle market and calibrates the model to this market. The third section examines the market power debate that has evolved in the U.S. slaughter cattle market and examines 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.

## Distributional Effects of Quality Measurement

The key assumption of this 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, investment decisions in genetics and management[1], or any other reason, have higher average quality agricultural products than other producers. When quality is not measured or measured with a high degree of inaccuracy, the market determines an average price over quality and high quality producers are implicitly subsidizing low quality producers. An increase in the level of quality measurement removes some or all of this implicit subsidy by raising the average price 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 formalize 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, since the U.S. slaughter cattle market will be used for calibration, denote the qualities 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. Label the probabilities of these errors $u_{S|C}$ and $u_{C|S}$, respectively. The error probabilities represent the level of quality measurement and an increase in the level of quality measurement is represented by a decrease in the error probabilities.

Label the fraction of total marketings that are choice for a given marketing period $\lambda$ (in the U.S. slaughter cattle market, marketing and price discovery occur weakly). 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. Label these probabilities $\pi_{S|C}$ and $\pi_{C|S}$, respectively. Expressions for these can be derived:

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

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

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.

The processor (buyer) has some valuation of choice and select derived from their output market. Label these valuations $v^C$ 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:

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

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

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 producers a uniform number of products (e.g. each cattle feedlot sells one pen of 100 cattle each marketing period) and that the quality distribution of producer $i's$ product is $\lambda_i$. Producer $i's$ product will grade $\tilde{\lambda}_i = (1-u_{S|C})\lambda_i + u_{C|S}(1-\lambda_i)$ and 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, i.e. $\lambda_i > \lambda_j$ 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, $p_i = \overline{p} = v_i$. A producer with below average quality, $\lambda_i < \lambda$, receives a price below the market average but above the true valuation of their product, $v_i \le p_i \le \overline{p}$ (the first weak inequality is strict if there is imperfect quality measurement and the second weak inequality is strict is there is at least some quality measurement, however imperfect). A producer with above average quality, $\lambda_i > \lambda$, receives a price above the market average but below the true valuation of their product, $v_i \ge p_i \ge \overline{p}$. 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. Since 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 $\overline{p}$ 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 subsidy 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 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. This pattern of support and opposition matches recent changes in the level of quality measurement in the U.S. slaughter cattle very closely.

## U.S. Slaughter Cattle Market

The U.S. 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 1997, 27,328,190 head of cattle were traded with a total value of US$20,365,894,000. About 70% of transactions take place in what this paper will call the traditional spot market, which emerged after the decline of terminal markets in the 1960 and 1970's. 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 they wish to purchase. Feedlots sell to the highest bidder.

It has long been recognized that the cattle traded are of heterogeneous quality and the U.S. 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[2]. 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 pens background and feeder management, which provides an indication of what the pen's quality should be. Procurement agents then appraise the quality distribution (quality and yield grade) of the pen by conducting a quick visual appraisal. 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 very inaccurate 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 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 imputed choice to select price spread in the slaughter cattle spot market[3,4]. Figure one presents these spreads weekly from 1997 to 1999. The boxed-beef spread (labelled BB 550-700 Spread) averaged \$7.25/cwt while the spot market spread averaged \$1.53/cwt, with a sample correlation coefficient of 0.77 (the correlation of first differences is even lower and ranges from 0.20 to 0.28). Although there is some differentiation based on quality, it can be seen that the industry literature's characterization of the spot market as an average price market is close to accurate. Tables 1A and 1B provides summary and descriptive statistics for these time series.

These data, along with market average quality[5], can be used to calibrate the model from the previous section. Since data are primarily available for the choice to select spread, it is convenient to express the model in terms of this spread:

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

Writing this in terms of the model's parameters yields:

$$P^C - P^S = (v^C - v^S)\frac{(1 - u_{S|C} - u_{C|S})\lambda(1-\lambda)}{(1 - u_{S|C} - u_{C|S} + 2u_{S|C}u_{C|S})\lambda(1-\lambda) + u_{C|S}(1 - u_{C|S})(1-\lambda)^2 + u_{S|C}(1 - u_{S|C})\lambda^2}$$

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, $P^C - P^S = (v^C - v^S)(1 - \pi_{S|C} - \pi_{C|S})$. The observed shrinkage from \$7.25/cwt to \$1.53/cwt indicates a value in the range of 80% for $\pi_{S|C} + \pi_{C|S}$.

The asymmetry of measurement error in the last two terms of the denominator assures separate identification of the errors as long as $\lambda \neq 0.50$. When the quality distribution is 50/50, the quality price spread 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% and after adjusting for the grid market selection (see below) the average was 52.8%. Separate identification was not obtained and $u = u_{S|C} = u_{C|S}$ was imposed to improve numerical performance.

Using least squares criteria to fit the above equation (see Whitley, 2000, for a detailed discussion of the calibration exercise), the estimate of $u$ was 40.20%. Computing $\pi_{C|S}$ and $\pi_{S|C}$ for each market week and taking the average gave estimates for these of 42.98% and 37.55%. This implies that, on average, from 1997 to 1999 an animal that visually appraised choice had a 38% chance of actually being select and an animal that visually appraised select had a 43% 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 lost $2.66/cwt on animals that grade choice is the reason high quality producers desire higher levels of quality measurement and the $3.01/cwt gain on animals that grade select is the reason low quality producers oppose higher levels of quality measurement.

The last decade has seen the emergence of an alternative marketing channel in the U.S. 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 U.S. 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% of all market transactions. At the transaction date, a schedule of premiums and discounts over quality traits and a base price (or formula to determine a base price) are agreed upon by buyer and seller (the schedule of premiums and discounts constitutes the "grid"). The animals are shipped to the packer and slaughtered. Prior to fabrication, the carcass is graded[6] and the results recorded. Price computation and payment dispersion generally occur within three to four days of delivery at the plant.

Figure one illustrates the grid choice to select price spread along with the previously discussed boxed-beef and spot market spreads (table 1A provides summary statistics and table 1B provides sample correlations). Not only has the grid spread followed the boxed-beef spread closely (their correlation coefficient is 0.98), but the mean of the grid spread is $7.40/cwt compared with $7.25/cwt for the boxed-beef spread[7]. Although base price adjusts when moving from the spot market to the grid market, the change from a $1.53/cwt to a $7.40/cwt choice premium is quite large (cattle prices average $103/cwt and the feeders margin after feeder calf and feed purchases averages $6/cwt to $7/cwt).

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 (which are highly concentrated with a national average four firm concentration ratio of 70% to 80%). Although market power is 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 pushing 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 1980's 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 (U.S. 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 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-subsidization is compatible. Multimarket price discrimination is also compatible. If a more 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 favor an alternative marketing channel that would differentiate them from the other producers. This paper will not be able to definitively differentiate these two possibilities, but some suggestive evidence that quality differentials alone are able to explain price differentials between the two markets is offered in the following section.

## 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 the quality measurement was serving as a screening device to separate the producers into two groups (high quality/high elasticity of supply producers and low quality/low elasticity of supply producers). Substantial empirical work has attempted to measure the relationship between the level of non-spot market prices (mostly gird priced cattle) and the spot market price and the result has consistently been a negative, but small, relationship. Elam (1992) estimated a price equation with number of contract cattle as an explanatory variable and found that a 1,000 head increase (nation wide) in monthly forward contract transactions is associated with a $.003 to $.009 per cwt. decrease in the U.S. average spot price (or roughly that a 1% increase in contract cattle was associated with a $.70 to $2 per head decrease in spot market price). Schroeder et al. (1993) estimated that the presence of non-spot market transactions were associated with a $.15/cwt to $.31/cwt decline in spot market price ($1.50 to

$3.40 per head). Ward et. al. (1996) estimate several relationships, including that a 1% increase in captive supply deliveries results in a $.10/cwt to $.41/cwt decline in spot market price. Hayenga and O'Brien (1992), however, only find a significant negative correlation in Kansas in their study of Colorado, Kansas, Texas, and Nebraska. Schroeter and Azzam (1999) confirm the negative relationship using data from the Texas panhandle.

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 and the average quality in the spot market declines, lowering the average price in the spot market. The relevant question is thus whether or not quality alone can explain the observed price declines in the spot market. Multimarket price discrimination would imply a differential larger than quality 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%) 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% higher quality than the plants sold to. U.S. Premium Beef averaged 67.3% choice or prime and 61.3% Y.G. 1 & 2 marketings for 1999. The national average for 1999 was 56.0% choice or prime and 51.2% Y.G. 1 & 2. These higher quality cattle receive higher prices. In 1999, National Farms averaged (over pens) $1.32/cwt in quality premiums. U.S. Premium Beef averaged $14.85/head in premiums ($1.98/cwt for a 750 pound carcass)[8].

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 level of grid pricing can be approximately weekly. This section develops a simply model of quality supply to compute rough estimates of the level of quality selection and expected price differential between marketing channels.

For a given marketing week, denote the price level of select cattle as $p$, the quality premium for choice as $\lambda$, and the price of corn as $p_C$. For an individual producer, the choice variables are the quantity of cattle to sell in a marketing week, denoted by $q$, and the quality of the cattle, denoted by $\lambda$. The producer's profit function is given by:

$$\pi = (p + \lambda S)q - c(q, \lambda; p_C),$$

where $c(q,\lambda;p_C)$ is a cost function with corn price as the primary cost shifter. The first order condition for the grade of quality is $Sq = c_\lambda(q,\lambda;p_C)$. Solving both first order conditions yields the supply curve of quality, $\lambda^* = h(S, p, p_C)$.

To allow for differences in managerial ability and the self-selection of better managers into grid priced marketing alternatives, extend the above supply function to $\lambda^* = h(S, p, p_C, \alpha)$ where $\alpha$ is the managerial talent of the manager. A first order Taylor series approximation to the above function is provided by $\lambda^* \approx \beta_0(\alpha) + \beta_1(\alpha)S + \beta_2(\alpha)p + \beta_3(\alpha)p_C$ [9]. Suppose there are two types of managers, $\alpha^H$ and $\alpha^L$, and that there is perfect selection of high ability managers into the grid pricing marketing channel. Producers face different quality premiums and price levels in the two markets as well, but assume that these are only multiplicative shifts of each other and that the shift parameters can be rolled into the parameter values, this is necessary because only the grid premiums are obtainable and only the spot market price level is obtainable. Under these assumptions, the supply functions for a firm in the spot market and the grid market become:

$$\lambda^S \approx \beta_0(\alpha^L) + \beta_1(\alpha^L)S + \beta_2(\alpha^L)p + \beta_3(\alpha^L)p_C$$

$$\lambda^G \approx \beta_0(\alpha^H) + \beta_1(\alpha^H)S + \beta_2(\alpha^H)p + \beta_3(\alpha^H)p_C.$$

If all firms are identical in size and $\gamma$ is the fraction of total marketings that are grid priced, then the market average quality is $\lambda = \gamma\lambda^G + (1-\gamma)\lambda^S = \lambda^S + \gamma(\lambda^G - \lambda^S)$. Substituting the approximations in and relabelling the variables yields:

$$\lambda \approx \beta_0 + \beta_1 S + \beta_2 p + \beta_3 p_C + \gamma(\alpha_0 + \alpha_1 S + \alpha_2 p + \alpha_3 p_C),$$

where $\lambda^G - \lambda^S = \alpha_0 + \alpha_1 S + \alpha_2 p + \alpha_3 p_C$.

Data on each of the variables above are available for nine quality traits: prime, choice, select, Y.G. 1 to Y. G. 5, and bull/non-bull. See the data appendix and Whitley (2000) for a complete discussion of the data and empirical methods used in estimation, estimations were performed separately for each quality trait. Table 2A presents the estimates of $\lambda^G - \lambda^S$ for each of the nine quality traits (three year average of the weekly difference), three seasonal dummy variables were included in the regression. As can be seen, there is a statistically significant difference for choice, Y.G. 1, and Y.G. 3. Grid priced cattle average a 12.51% higher grading choice (if 50% of spot market cattle graded choice, then 62.51% of grid price cattle graded choice), similarly grid price cattle average 9.06% fewer grading Y.G. 1 and 18.55% more grading Y.G. 3[10].

These results can be used to infer average price differences across marketing channels (direct data is not available on this). If $p^S$ is the average price in the spot market and $p^G$ is the average price in the grid market, then for one grade of quality the price differential is computed by $p^G - p^S = S(\lambda^G - \lambda^S)$. Adding over the nine grades of quality gives the total expected price differential. The overall market average price is $p = \gamma p^G + (1-\gamma)p^S$ and the difference between the overall market average price and the average price in the spot market is given by $p - p^S = \gamma(p^G - p^S)$.

Using all nine quality characteristics[11], the estimates in table 2A predict a price difference between grid and spot market cattle of \$3.69/cwt (standard error 0.83) and a price difference of \$0.68/cwt (standard error 0.15) between the overall market average price and the spot market price. 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. 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.

There is an obvious endogeneity problem with the above regression, estimating supply without controlling for demand. Since marginal fabrication costs do not vary widely over carcasses of varying quality, it will be assumed here that quality price differentials largely pass through the packing plant and are sufficiently exogenous to be used without concern. This is not reasonable for the price level, however. To control for this potential problem, several alternative estimations were performed. Table 2A presents the two price differentials for some of these alternatives. Estimation one is the previous estimation. Estimation two uses pork and chicken wholesale prices (demand shifters) and all exogenous variables as instruments for price level. Estimation three uses the nearby live cattle futures contract price and all exogenous variables as instruments for price level. Estimation four drops price level form the regression. Finally, for comparison estimation five presents the ad hoc linear specification $\lambda = \beta_0 + \beta_1 \gamma + \beta_2 S + \beta_3 p + \beta_4 p_C + \eta$ results with wholesale pork and chicken prices (and all exogenous variables) used as instruments for price level. As can be seen, the results are robust[12].

Although low data quality and limitations on data availability prevent more rigorous empirical examination at this point, the available data can be used to estimate the level of quality selection and the results are suggestive that quality differentials along can account for price divergences between marketing channels and the negative relationship between the level of non-spot market transactions and spot market price.

## 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. This paper has presented a simple model of imperfect quality measurement that is compatible with this pattern of opposition and support and, when calibrated to the U.S. slaughter cattle market, implies price effects large enough to be driving observed actions. Empirical estimates demonstrate that quality is both an economically and statistically significant factor in explaining recent changes.

The model in the first two sections of this paper has followed the literature and assumed that quality supply is perfectly inelastic. An exogenous, perfectly inelastic factor like managerial talent or weather determined $\lambda_i$ and there was no endogenous response to the level of quality premiums. This is a serious defect of the current literature and this paper. Quality is a choice variable that is conceptually no different than quantity. The transaction costs of measuring quality are often much higher than the costs of measuring quantity in the real world. Future theoretical research that begins to examine the producer's choice of quality level and the market's choice of the level of quality measurement directly is very important.

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 this paper began to be collected in 1997. As the quantity and quality of data improve, more rigorous and thorough empirical work will be possible. This is another important area for future research.

# End Notes

[1] Actually, the difference is presumably driven by some inelastic factor making investment decisions endogenous to one of the first two (or some other driving factor).

[2] 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 the final consumers.

[3] Since the marginal processing costs for choice and select cattle are very similar, the choice to select boxed-beef price spread serves as a proxy for the packer's input valuation spread.

[4] No quality prices exist, per se, in the spot market since only average prices are realized for a pen of heterogenous cattle. The *Weekly Weighted Average Slaughter Cattle Prices* report does provide sufficient data to impute a choice and a select price. See the data appendix for a brief description of the procedure used and Whitley (2000) for a more detail discussion. The data and Matlab code 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 $b_j = {}^{2*\sin(\pi j/3)}\!\big/_{\pi j}$. These weights were approximated with the filter $y_t = 0.1039x_{t-2} + 0.2077x_{t-1} + 0.3768x_t + 0.2077x_{t+1} + 0.1039x_{t+2}$.

[5] True market average quality ( $\lambda$ ) is known because this data is taken from measurement that takes place in the processing plant, not visual appraisal in the spot market.

[6] 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.

[7] 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.

[8] U.S. Premium Beef data are from their publication *USPB Update*. The National Farms statistics are from raw data provided by Mr. Glenn Poe.

[9] As is indicated below, there is not high variation in quality, indicating that a linear approximation should be sufficient. A second order approximation was also regressed and there were no significant changes in the results.

[10] There is a trade off in management between quality grade and yield grade. The higher quality grade premiums thus skew management towards quality grade and away from yield grade.

[11] Using only the statistically significant quality differentials yields slightly larger results.

[12] Also examined were quadratic approximations to the supply function and different assumptions about the quality premiums in the spot market. Although the specification didn't allow for complete log transformations, partial log models were regressed as well. All results were similar to those reported in table 2B.

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# Data Appendix

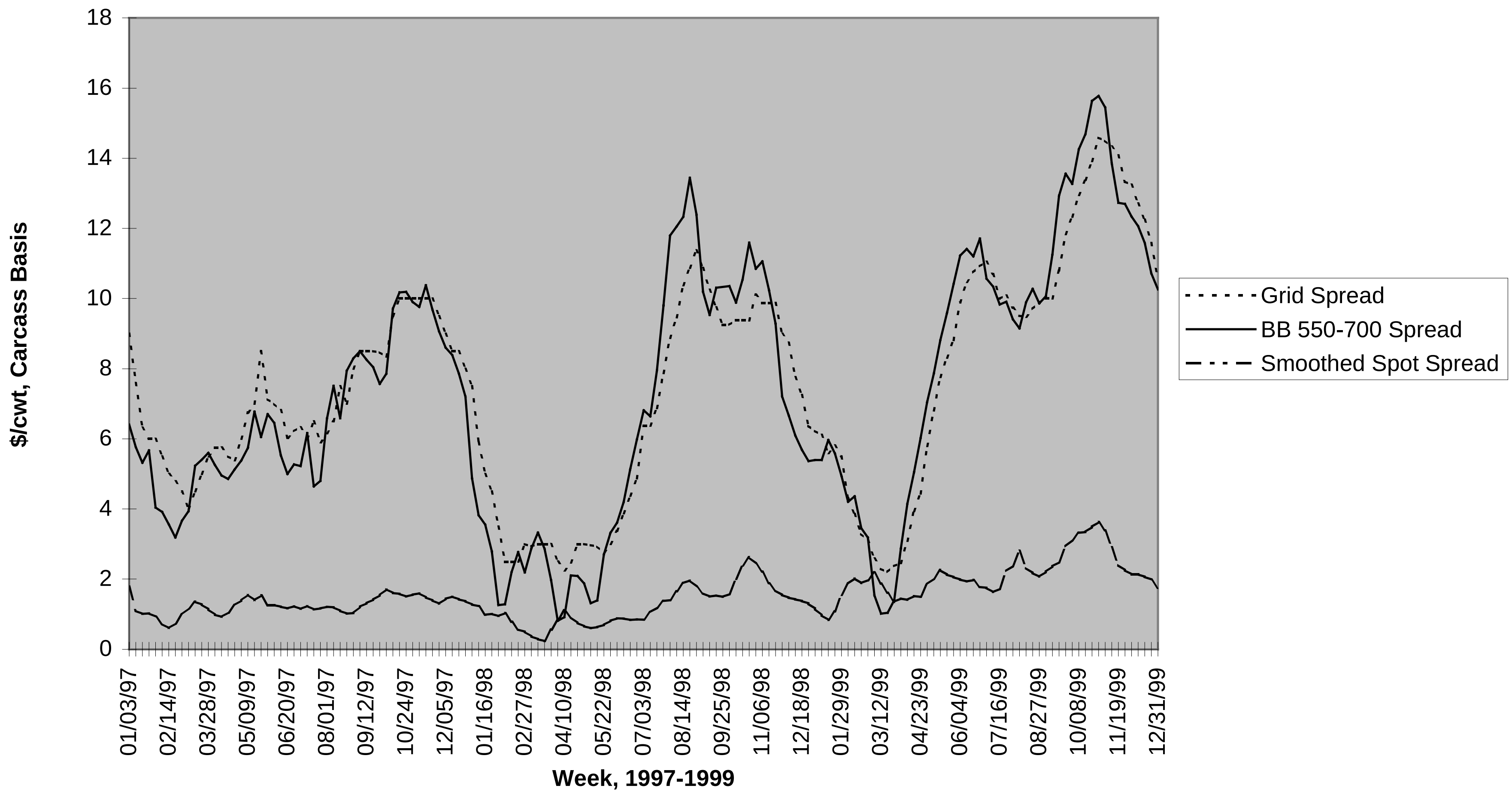
The majority of the data used in this paper is from USDA market news reports and covers the 157 weeks from 1997 to 1999. Table 1A provides summary statistics for selected variables. The *Estimated Composite of Boxed Beef Cut-Out Values Report* constructs a daily estimate of the value of a fabricated 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. Since fabrication costs are 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 three). The *National Premiums and Discounts for Slaughter Steers and Heifers Report* collects at the beginning of the week by phone survey 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 *Weakly Weighted Average Slaughter Cattle Prices Reports* were used for 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/So. Minnesota. These regions accounted for 73% of total federally inspected U.S. slaughter from July to December, 1999. The quality categories are pens that visually appraise 0%-20% choice, 20%-35% choice, 35%-65% choice, 65%-80% choice, and 80%-100% 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%-80% range is 72.5% 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% dressing percent (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 CO, IA, KS, NE, OK, TX, and Southern MN. The quality report includes these states (except Southern MN) and AR, LA, MO, NM, MT, ND, SD, UT, and WY. From June to December 1999, these additional states accounted for less than 4% 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, TX/OK, KS, CO, and NE/WY. For these regions, the report lists cash sales and additional movement, which includes: a) cattle that are fed by or for packers; b) contract or formula agreements; c) cattle financed by packers and slaughtered by the same packer; and d) 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.

**Figure One: Choice-Select Price Spreads**



| Table 1A: Summary Statistics and Correlations of Constructed Variables | | | | | |
|---|---|---|---|---|---|
| Variable | Mean | Median | Std. Dev. | Minimum | Maximum |
| Grid Ch-Se Spread | $7.40/cwt | 7.25 | 3.18 | 2.21 | 14.58 |
| BB Ch-Se 550-700 | $7.25/cwt | 6.70 | 3.67 | 0.81 | 15.78 |
| BB Ch-Se 700-850 | $7.16/cwt | 7.02 | 3.69 | 0.23 | 16.45 |
| Spot Ch-Se Spread | $1.53/cwt | 1.43 | 0.80 | -0.13 | 4.38 |
| Smoothed Spot Spread | $1.53/cwt | 1.43 | 0.65 | 0.24 | 3.63 |
| Fraction Choice+ | 54.63% | 53.99 | 3.15 | 48.64 | 62.68 |
| Fraction Y.G. 1&2 | 54.28% | 54.42 | 2.29 | 49.48 | 59.79 |
| Cattle Price Level | $103.00/cwt | 103.49 | 4.99 | 90.99 | 112.67 |
| Corn Price | $2.25/bu. | 2.32 | 0.36 | 1.67 | 2.88 |
| Grid Pricing | 18.18% | 18.32 | 4.28 | 8.37 | 29.95 |

| Table 1B: Correlation Coefficients of Quality Spreads | | |
|---|---|---|
| | Spot Market Spread | Smoothed Spread |
| Boxed-Beef, 550-700 | 0.635 | 0.773 |
| Boxed-Beef, 700-850 | 0.652 | 0.788 |
| Grid | 0.619 | 0.746 |

| Table 2A: Quality Selection Across Marketing Channels (Standard Errors in Parenthesis) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quality Trait | | | | | | | | |
| Coefficient | Prime | Choice | Select | Y.G. 1 | Y.G. 2 | Y.G. 3 | Y.G. 4 | Y.G. 5 | Bulls |
| Captive Supplies | 1.09<br>(1.21) | 12.51<br>(4.52) | -0.55<br>(4.97) | -9.06<br>(2.56) | 3.51<br>(3.75) | 18.55<br>(3.76) | 0.18<br>(0.42) | -0.04<br>(0.05) | 0.02<br>(0.28) |
| Market Ave. Quality | 0.0216 | 0.5247 | 0.3607 | 0.1094 | 0.4334 | 0.3355 | 0.0119 | 0.0009 | 0.0114 |
| Ave. Quality Premium | $6.0732/cwt | 7.3962 | 10.0027 | 0.6791 | 1.3116 | 14.9276 | 4.9745 | -4.9745 | -28.1029 |

| Table 2B: Sensitivity to Specification[a] | | | | | |
|---|---|---|---|---|---|
| | Estimation | | | | |
| Estimate | 1 | 2 | 3[b] | 4 | 5 |
| Grid Price Less Spot Price | 3.69 | 3.74 | 3.65 | 3.77 | 3.70 |
| Overall Market Price Less Spot Price | 0.68 | 0.68 | 0.67 | 0.69 | 0.68 |

[a] All values $/cwt.
[b] Estimated from March, 1997, to December, 1999.