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Abstract
The primary pro-competitive justification for multiple principals to hire a common bidding agent is efficiency. The efficiency gained by doing so increases the advantage of the common bidding agent. *Almost common value* auction theory predicts that an advantaged bidder is able to reduce competition by credibly enhancing the 'winner's curse' of disadvantaged rivals. The credible threat results in disadvantaged rivals exiting the bidding process early, leaving the advantaged bidder to purchase most, if not all, units at lower prices than when rivals have common values. The results of our empirical study of a common bidding agent are consistent with this theory.

Auction Prices, Market Share, and a Common Agent

1. Introduction

Auction owners and sellers of cattle have long been concerned that multiple principal buyers hiring a common bidding agent has adverse effects on competition and prices (USDA, GIPSA, 2000 to 2004).[1] Competition is allegedly reduced by the reduction in the number of bidders and collusion among the principals of the common bidding agent. On the other hand, buyers claim they hire common agents to reduce agency costs and others argue that common agency enhances efficiency by reducing transactions costs in order for small to medium sized firms to be able to compete with larger rivals (Informa Economics, 2010; Koch Group, 2005 and Telser, 1985).

If common agency results in efficiencies, then the principals gain a competitive advantage over their rivals. The buyers' own defense may result in yet another anticompetitive outcome. Common value auction theory predicts that when one bidding agent is endowed with a cost advantage, the advantaged bidder will win most of the items at lower prices due to decreased competition from disadvantaged rivals (Bikhchandani, 1988; Klemperer, 1998; Rose and Kagel, 2008).[2] However, neither experimental nor empirical results support the reduced competition findings of this theory (Levin and Kagel, 2005; Rose and Levin, 2008; Nelson 1997).

This paper provides the first empirical analysis of a common agent's impact on auction prices and the distribution of purchases among the remaining rival bidders, leaving the collusive aspects and evidences for future research. Our results indicate that the common bidding agent buys more units and pays significantly lower prices than independently represented bidders. These results support both the seller concerns and theoretical predictions of an advantaged bidder. At the same time, these results are also consistent with enhanced efficiency as claimed by buyers. While our results are consistent with enhanced efficiency as claimed by buyers, indirect evidence suggests that the use of a common agent appears to be accompanied by some loss of sellers' welfare in our sample.

2. Market Setting and Auction Description

Roughly $25 billion of livestock are sold at auction and 3,883 professional buying agents, including commissioned order-buyers and dealers, purchased $26.4 billion in livestock (USDA, GIPSA, 2008). Professional buying agents typically represent multiple principals at auction.[3] Livestock auctioneers use an open-outcry English auction format selling live animals either in groups or one at a time.

The setting for our analysis is a local auction where cull cows are sold one at a time. Nearly all bidders have multi-unit demand. Most cull cows are purchased for direct delivery to beef packers. Beef packers routinely establish long-run agreements with their bidding agents, be it employed or contracted. Beef packers disassemble cow carcasses to produce relatively homogenous categories of meat and meat by-products. However, cull cow carcasses are heterogeneous as to their individual contribution of total meat, categories and quality of meat products. Because cull cows are sold live, bidders must rely on a set of imperfect signals of each animal's true aggregate output value via visual appraisal of the animal's observable physiological attributes (O'Mara et al., 1998; Gresham et al., 1986). Each animal's true carcass value is common to symmetric processors, because the components of the carcass within quality specifications are also uniform in value (United States Department of Agriculture, Agricultural Marketing Service). Based on this description, the auction is best characterized as a sequential common value English auction for stochastically independent goods. This description guides the literature we use to develop our conceptual and empirical models.

3. Conceptual Model Development

We rely primarily on common value auction theory and empirical work to develop our conceptual model in regards to: i) advantaged bidders; ii) bidder concentration; iii) potential endogeneity between winning bids and concentration and iv) agent learning in repeated auction games. We also use predictions from theory to formulate testable hypotheses in the data.

Valuation asymmetries in common value auctions result in an advantaged bidder and are referred in the literature as *almost-common value auctions* (Klemperer, 1998; Levin and Kagel, 2005). The extra value advantage given any private signal holder may be due to either lower cost of production or an output value advantage or both. Generally, the theories developed by Bikhchandani (1988), Klemperer (1998), and Rose and Kagel (2008) predict that the disadvantaged bidders reduce their bids in order to avoid the heightened winner's curse caused from bidding against an advantaged bidder. Hence, in second-price and English auctions the advantaged bidder is expected to win more often and pay lower prices than when bidders have symmetric common values.

It has been demonstrated that as the number of bidders increases, so shall winning bids (Laffont 1997). Empirical studies of repeated English auctions have found a positive relationship for used cars (Nelson, 1997) and cattle (Bailey et al., 1993). These studies utilized *ex post* calculations of bidder concentration measured by the total number of winning bidders (Nelson, 1997) or by the Herfindahl-Hirschman Index (HHI) (Bailey et al., 1993). However, the effect of the number of bidders on winning bids is not necessarily positive in the common or affiliated value setting especially when entry is endogenous (Pinske and Tan 2005; Li and Zeng 2009). Empirical studies in repeated auctions have found a negative correlation in eBay auctions (Bajari and Hortaçsu, 2003). Though the number of bidders necessarily influences winning bids, theory is inconclusive and we leave this relationship as an empirical question.

The number of bidders is characterized as an exogenous factor on winning bids (Laffont, 1997). However, this presupposes that all potential bidders are committed to bidding from the outset (Levin and Smith, 1994). In real-world auctions, bidders freely enter and exit the bidding process where entry by a subset of potential bidders may be endogenously determined by a zero-profit condition (Klemperer, 1999; Levin and Smith, 1994). Levin and Smith (1994) conclude from single unit auction theory that endogenous entry may explain why the number of bidders varies in repeated auctions of similar items. Bajari and Hortaçsu (2003) support the supposition of Levin and Smith (1994) by analyzing eBay auctions based on a common value modeling approach. Experimental tests of endogeneity in common value auctions have shown that, as bidders evaluate their heterogeneous opportunity costs of entry, increasing expected profits in the auction invite entry thus increasing the size of the market (Cox et al., 2001).

In the market setting just described, principal purchasers are not assumed to have homogenous preferences on any given day. For instance, packers typically establish sales agreements prior to purchasing their inputs. Their customers place orders for a variety of meat products. Maximizing efficiency dictates that packer 'fit' their purchases to best meet their customers' demand. Because cattle are heterogeneous, we expect that the number of bidders to vary for any given unit.

Finally, players in repeated games are expected to be adaptive learners (Roth and Erev, 1995; Camerer, 2003, pp. 469-470). Camerer (2003) concludes that there is 'strategic teaching' between auction participants and Gavin and Kagel (2002) demonstrate that bidders follow simple learning processes in repeated common value auctions. Because bidders are not pre-committed in our setting, each bidder cannot observe the degree of rivalry they will face for any given unit *ex ante*. The history of play provides signals as to the current level of competition. Therefore, learning captures bidders' updated beliefs about the level of price competition derived from the expected number of bidders they will ultimately face for each unit

Utilizing the guidance of the literature just presented and the description of the auction setting, the conceptual recursive model follows.

$$p_i = f(n_i, \phi_i, \kappa_i \mid p_{i-j}) \quad (1)$$

$$n_i = f(k_i \mid n_{i-j}) \quad (2)$$

where p_i is the price paid and $n_i \in N$ is the number of bidders competing for the i^{th} unit. $\phi_i \subset \Phi \equiv f : P \to A = \{c, a_1, ..., a_{n-1}\}$ is the subset of n bidding agent types competing for the i^{th} unit on behalf of P principals, where type is determined from the mapping of contractual relationships between P principals and A agents. In the presence of common agents, $N < P$ and $N = P$ otherwise. Heterogeneity in output value among units sold is $\kappa_i \subset K$. Allowing for principals to have heterogeneous preferences results in $k_i \subseteq \kappa_i$; it is not required that the same subset of unit characteristics impact entry into bidding as those that determine price. Finally, p_{i-j} and n_{i-j} is the information set of the history of play from which bidders learn and form expectations of the opportunity cost of entry related to price and competition.

4. Data

The data used for the analyses are provided by an auction company in Wisconsin and data span October 4, 1999 through January 26, 2000. The data were collected by the auction company in support of a complaint regarding anticompetitive activities of common agents filed with the Grain Inspection, Packers and Stockyards Administration (GIPSA) – an antitrust regulatory arm of the United States Department of Agriculture.[4] A basis for the auction company's concern was that average weekly prices at the auction were significantly lower than regional prices (figure 1, data description and statistical analysis are provided in the following footnote).[5] Due to the original intended use of the data and unique attributes to be described, more recent observations are not available. The most unique feature of our data is that the auction firm identified the type of business engaged in by the principals and the principal/agent relationships.

There are 34 separate sale dates during this time frame containing 7,722 individual sales, averaging 227 head per auction. The number of bidders per animal is not recorded due to the logistical constraints of the open-outcry method of taking bids and the speed at which units are traded. Observations were recorded on scale tickets. A scale ticket specifies a ticket number, a number to identify the animal, the date and time of the sale, along with the breed, weight, and any noted negative physical attributes of the animal. The physical attributes of the cattle, such as breed and negative attributes were collected upon special request and are not publicly available. The cattle are not sorted by type resulting in a random arrival of physical attributes presented to the bidders.

The configuration of principals and agents at the auction is detailed in table 1 and is summarized as follows. Four principal buyers owning five meat processing facilities are officially represented. These firms constitute all but one of the primary beef processors within approximately 200 miles of the auction. We refer to the represented processor principals as Prin1, Prin3, Prin4, Prin5 and Prin7, and each is estimated to slaughter on average 600, 1500, 1200, 750 and 900 animals per day. Prin1 and Prin4 are processing plants owned in common. No processor represented enjoyed a significant transportation advantage at the auction.

Additional principal purchasers include: a commission order-buying firm (Prin2), two producer/dealers (Prin6 and Prin9) and a producer (Prin8). "Other" principals included one-time or infrequent purchasers. The auction company suspects that Prin2 and Prin6 were buying for processors. Thus, processor purchases were likely as high as 92 percent of the market. Important to this study, one commissioned order-buying agent at the auction, the common agent, bids on behalf of multiple principals: Prin1, Prin2, Prin3 and Prin4. The common agent has consistently represented these principals for many years prior to the collection of the data.

Table 1 also reports the number of head, average prices and average live weights purchased by each principal over the 34 auctions. *The common bidding agent (CBA) purchased 73.72 percent of the total available units for sale.* All other independent bidders purchased the remaining 26.28 percent and are collectively referred to as the independent bidding agents (IBAs). CBA's principals maintained nearly identical market shares of the common agent's purchases during the period of study (Prin1 & 4 = 35, Prin2 = 32.5 and Prin3 = 32.5 percent). CBA purchased cattle for Prin4 only from October 4 through November 8; no additional cattle were purchased for Prin4 at later auctions resulting in a market share distribution of Prin1 = 33, Prin2 = 33.3 and Prin3 = 33.7 percent for the remaining time period.

The average price was $33.71/cwt and the average live weight was 1,283.18 pounds (table 1). Holstein dairy cows constituted the majority (75.33 percent) of cows sold. About 14.28 percent of the total units traded had negative attributes.[6]

CBA's average winning bid was $1.23/cwt (3.6 percent) below the average winning bid. IBAs paid on average $3.41/cwt (10.11 percent) above the average winning bid which constituted a spread between the two bidder types of $4.64/cwt or 12.5 percent price advantage. Although all principals purchased all measurable physical attributes of cows, there appeared to be preference differences that contribute to the observed price differentials. For instance, the average weight of cows purchased by CBA was 1,257.74

pounds, while the average weight of animals purchased by IBAs was 1,354.56 pounds, a difference of 7.7 percent. Prin5 purchased the heaviest cull cows (1,602.64 pounds) at the highest average price ($40.77/cwt), while CBA purchased the lightest animals (1,095.57 pounds) on behalf of Prin1 at an average price of ($26.61/cwt). These price-weight relationships are expected, because heavier cows tend to yield more red meat and higher valued cuts of meat (O'Mara et al. 1998; and Gresham et al. 1986).

The proportions of Holsteins bought by principals were heterogeneous, ranging from 56.95 (Prin2) percent to 93.29 percent (Prin9). CBA purchased a high percentage of animals on behalf of Prin1 with noticeable defects relative to total purchases (42.41 percent). This partially explains in aggregate the lower average price paid by CBA, because a significant percentage of CBA's purchases with negative attributes were for Prin1 (25.28 percent). All other principals tended to purchase cows with a lower incidence of negative attributes – the proportion of purchases with no negative attributes ranged from 88.38 percent to 97.63 percent of their total purchases. Clearly, principals have heterogeneous preferences over types.

Finally, a thorough definition of the market is in itself a research question.[7] We rely instead on definitions of cattle markets provided by the courts, regulatory bodies and our data. From the available information we define the market as cull cows at a local auction and identify all bidders for cull cows as competitors.[8]

Based on our definition of the relevant market and the likelihood that most animals were purchased on behalf of processor principals, the HHI based on plant capacities of all potential processor competitors is 1,888 (table 1). However, the concentration at the auction is 3,631 based on verified processor principals, versus 2,303 based on suspected or potential processor principals. Thus, concentration of processor principals within the region is highly concentrated and more so at auction.[9] Interestingly, the *ex post* calculation of the HHI based on actual bidder purchases is 5,593 while the concentration of all participating principals is 1,971. This indicates that the presence of the common agent significantly increase concentration at the auction.[10]

5. The Empirical Model

The data in this study are sequential auctions for stochastically independent goods. Though the series include intermittent breaks across auction sessions, we treat the data as continuous. Following the conceptual model, we estimate a recursive system of equations to account for the endogeneity of bidder concentration.[11] To isolate the price impacts of the common agent, while accounting for the history of play within each auction day, we develop a dynamic measure of bidder concentration as each unit is traded. Finally, we control for the heterogeneous impacts on the value of the marginal yields related to the available live animal characteristics and heterogeneous buyer preferences for attributes.

5.1. Measuring Bidder Concentration

Common to an open-outcry auction, our data do not include the number of bidders per unit as would be required for equations 1 and 2. Changes in the level of rivalry via measures of bidder concentration, therefore, cannot be based solely on changes in the number of bidders. Instead, we follow Bailey et al. (1993) approach in which the bidder (agent) level HHI is included as a proxy for changes in the level of rivalry. This measure responds well in empirical modeling of prices when Cournot behavior is an appropriate assumption (Whinston, 2008, pp. 97-99). The data demonstrate the industry is 'highly concentrated' by current antitrust standards. Also, Cournot oligopsony pricing has been repeatedly demonstrated in similar regional fed cattle markets (Koontz and Garcia, 1997). As such, firm level Cournot behavior is an appropriate assumption in the regional market analyzed.

Though the theoretical relationship between HHI and Cournot behavior is well established to describe firm level competition (Werden, 1991), this relationship has not been formally linked to strategic bidding behavior at the auction level. However, we believe there to be a linkage between regional and auction level competition, and vice versa, based on the following packer buying practices: i) principals develop their purchase orders by taking into account regional and auction level competition, ii) bidding agents execute their principal purchase orders while accounting for changes in bidding competition at auction, iii) bidding agents report to their principal purchasers during the auction of the level and nature of competition they face allowing the principal to update their purchase orders as needed.[12]

Unlike the *ex post* concentration calculations of past research our proposed calculation of the HHI allows us to account for the possibility of endogeneity in bidder concentration and winning bids, while accumulating bidder information regarding the dynamics of past strategic bidding behavior. Our concentration measure is a Cumulative

Herfindahl-Hirschman Index (CHHI): where, $\text{CHHI}_q = \sum_{i=1}^{n} s_{iq}^2 \equiv$ sum of the squared i^{th} = $(1,n)$ bidders market shares (s_i) up to the $q^{th} = (1,Q)$ unit sold in the auction session. Market share is measured by a buyer's proportion of winning bids during an auction session and is continually updated as individual units are traded. The boundaries of the CHHI are the same as the HHI , i.e., a value of 10,000 represents a monopoly. Therefore, the CHHI is an updated outcome from the sequential bidding process that informs all those present of the current state of bidder, and by extension, firm level rivalry.

There are two possible shortcomings to the concentration calculation in its current form, particularly when the same players compete across auction sessions (days). One, it considers each auction day as a discrete auction with no possibility for information spillover (adaptive learning) to the next auction. The second is that the CHHI is extremely volatile early in an auction day. Higher levels of volatility in CHHI provide less reliable information for bidders to account for the current and future level of competition within the auction day.

Given the likelihood of changes in principal demands not only within, but between auction days, the history of play should be carried over from the previous auction day while bidders take a 'wait and see' position which is quickly updated as the new auction begins. Because the concentration information conveyed from the immediately previous auction day is not likely considered separate and independent of the current auction day, an adjustment procedure is devised to account for bidder information updating which reduces the uninformative wide swings associated with early auctioned units (figure 2). The adjustment procedure is outlined in Appendix A.

The number of winning bidders in our data do not change greatly across auction days while bidder market shares are highly volatile (table 2). Figure 3 depicts an example from the data of the progression of the CHHI. Concentration is based solely on the winning bids observed by the bidders up to the unit sold, denoted by CHHIA, and is compared to the principal buyer concentration (CHHIP). On average, the CHHIP is 2,160 and the CHHIA is 5,667 (table 2) as compared to the *ex post* concentrations of 1,971 and 5,593 (table 1). Our measures of concentration are slightly greater than ex post calculations because the transition period does not completely eliminate higher concentration early in the auction. Because of the significant purchases by the common agent, decreases in the CHHIA are primarily due to entry by the fringe.

5.2. Common Agent and Bidder Concentration

To isolate the impacts of the common agent on price, we control for bidder heterogeneity. Because successive purchases by all bidders affect the CHHIA in the same manner, the effects of the common agent are controlled for only in the price equation. As calculated, the CHHIA increases with successive purchases by the same bidder. Admittedly, higher concentration is expected to be associated with the common agent on average.[13] However, accounting for heterogeneity of bidders in the concentration equation is not appropriate because the cumulative market shares by the common agent are used to calculate bidder concentration.

5.3. Learning

Because bidders are not pre-committed in our setting, each bidder cannot observe the degree of rivalry they will face for any given unit *ex ante*. The history of play provides signals as to the current level of competition. Therefore, learning captures bidders' updated beliefs about the level of price competition derived from the expected number of bidders they will ultimately face for each unit. Lagged endogenous variables are thus included in each own equation to account for the current information bidders have of the historical competition dynamics. The lag of CHHIA is not included in the price equation because bidders are already incorporating this information into their pricing decisions when they estimate the impact on concentration due to anyone of them winning the bid on the current unit. Conversely, the lag of price is not included in the concentration equation as the past prices have already been incorporated into impacts on previous concentration outcomes.

5.4. Output Values

Processor principals derive in part their purchase orders based on their output value. Increasing demand for their output corresponds to increased input demand. Carcass value provides a proxy for the total output value (Ward, et al., 1998). Processors report their negotiated meat sales daily to United States Department of Agriculture, Agricultural Marketing Service from which they calculate a corresponding carcass output value. We use the current auction day's carcass value to proxy output value.[14] These data were collected from the Livestock Marketing Center.

5.5. Hedonics and Principal Preferences

Both the price and concentration equations control for the physical characteristics of the live animal to account for the buyer's private marginal value product and demand preferences for each of the available characteristics. We rely on the significant correlation between the observable and other physiological indicators unobserved to the econometrician from which the buyer derives a signal of the animal's true carcass characteristics (O'Mara et al., 1998; Mintert et. al., 1990; Gresham et al., 1986). For instance, a cubic live weight relationship best explains the relationship between live weight and price because extremely light (heavy) cows receive greater discounts (premiums) due to disproportionally lower (higher) total red meat yield and yield of low (high) valued cuts of meat. Both Holsteins and cows with negative characteristics are expected to yield less red meat and thus are expected to experience a discount (O'Mara et al., 1998).

If a characteristic is more (less) preferred by principals and the agent accurately accounts for that preference in bidding, we would expect a positive (negative) impact on the concentration measure. As indicated in table 1, a squared live weight relationship is included in the concentration equation, due to fewer principals competing for cattle at the extreme weights. From the description of the data, both Holsteins and cows with negative characteristics are included as regressors with no *a priori* expectations as to their impact on concentration.

5.6. Across and Within Auction Trends

An overall trend variable is included in the price equation to capture market influences that unilaterally impact bidder behavior not explained in the model, for instance changes in futures prices, BSE and e-coli scares and international trade relations. An overall trend variable is included in the concentration equation to capture market impacts that are not symmetric across principal buyers, for instance losses and gains in major sales agreements.

A within auction trend variable is incorporated into the price and concentration equations to account for strategic behavior associated with a repeated unit auction. For instance, an 'increasing price anomaly' is predicted by Weber (1983) for repeated *identical* units, while a 'declining price anomaly' in repeated *stochastically independent* common value auctions is predicted by Fatima et al. (2005). Both of these theories are based on the premise that bidders are capacity constrained, risk-neutral, rational and able to backward induct.[15] Empirical results by Buccola (1982) provide evidence of the 'declining price anomaly' in repeated common value cattle auctions.

5.7. *Estimated System of Equations*

The system of equations and *a priori* expectations developed from theory and the data are as follows. Descriptive statistics for each variable are provided in table 2.

$$SP_t = \beta_0 + \beta_1 CHHIA_t + \beta_2 CBA_t + \beta_3 SP_{t-1} + \beta_4 CV_t + \beta_5 HC_t + \beta_6 Neg_t + \beta_7 Wt_t + \beta_8 Wt^2{}_t + \beta_9 Wt^3{}_t + \beta_{10} ST_t + \beta_{11} T_t + \varepsilon_t \quad (3)$$

where *a priori*:

$\beta_1 \neq 0,\ \beta_2 < 0,\ \beta_3 > 0,\ \beta_4 > 0,\ \beta_5 < 0,\ \beta_6 < 0,\ \beta_7 > 0,\ \beta_8 < 0,$
$\beta_9 > 0,\ \beta_{10} \neq 0$ and $\beta_{11} \neq 0$

and

$$CHHIA_t = \alpha_0 + \alpha_1 CHHIA_{t-1} + \alpha_2 HC_t + \alpha_3 Neg_t + \alpha_4 Wt_t + \alpha_5 Wt^2{}_t + \alpha_6 ST_t + \alpha_7 T_t + \upsilon_t \quad (4)$$

where *a priori*:

$\alpha_1 > 0,\ \alpha_2 \neq 0,\ \alpha_3 \neq 0,\ \alpha_4 > 0,\ \alpha_5 < 0,\ \alpha_6 \neq 0$ and $\alpha_7 \neq 0$

where:

$SP_t \equiv$ Selling Price (\$/cwt) of the t^{th} unit;

$CHHIA_t \equiv$ Cumulative Herfindahl-Hirschman Index of winning bidders for the agents/principals present at sale ranging from 0 to 10,000;

$CBA_t \equiv$ Common bidding agent dummy variable, taking a value of 1 if common agent wins the bid and 0 otherwise;

$CV_t \equiv$ Current day carcass value index for cutter (low grade) cows which takes on the same value for all within day trades;

$HC_t \equiv$ Holstein cow dummy variable, non-Holstein = 0;

$Neg_t \equiv$ Negative attribute dummy variable, non-negative = 0;

$Wt_t \equiv$ Animal weight in pounds;

$ST_t \equiv$ Within sale trend → order of units sold per auction;

$T_t \equiv$ Overall trend observation, 1 – 7,722;

$SP_{t-1} \equiv$ Selling Price lagged one unit sold (\$/cwt); and

$CHHIA_{t-1} \equiv$ Cumulative Herfindahl-Hirschman Index of winning bidders for the agents/buyers lagged one unit sold.

The identifying instrument for price is the previous concentration level while concentration is identified primarily by the successive purchases by agent type, previous price and output price expectations. As such, the price equation is just identified, while the concentration equation is overidentified.

6. Estimation Procedures and Results

We estimated the recursive system of equations. Following Bailey et al., a single price equation that ignores the potential for endogeneity of concentration and price is estimated to compare the results of using either the *ex post* HHIA or CHHIA.

Due to the time series attributes of the price data and the cumulative nature of the concentration measure, autocorrelation is a concern. In the presence of lagged endogenous variables, the lags must be instrumented in order for the Durbin-Watson statistic to be an appropriate test statistic for autocorrelation (Greene, 2003, pp. 277-78; Fair, 1970; Sargan, 1961). If autocorrelation appears to be a significant issue, the estimation of the stage equation standard errors are corrected using the conditional least squares method (SAS Institute, 2009, chapt. 14, pp. 794-799).

Next, the Wu-Hausman specification test which calculates a chi-squared distributed *m*-statistic is conducted to first test the null hypothesis that ordinary least squares (OLS) is more consistent and efficient as compared to an instrumental-variables estimation procedure (2SLS). If the null is rejected then three-stage least squares (3SLS) and 2SLS estimators are compared for asymptotic efficiency (Hausman, 1978).

Because the common agent purchases a significant portion of the cattle, collinearitity cannot be ruled out. Collinearity diagnostics in the system of equations are conducted on the Jacobian crossproducts matrix (Belsley et al., 1980).

The results provide evidence of the negative price effect associated with purchases by the common agent. The parameter estimates for equations (3) and (4) are reported in table 3. The estimated relationships are consistent with *a priori* expectations. Parameter estimates for a single price equation as used in past empirical literature are listed in table 4 for comparative purposes.

The Durbin-Watson statistic indicates that first-order autocorrelation was an issue for the concentration system equation. The low estimated *rho* in the price equation suggests that agent bidders regard bidding as a series of independent repeated events, leaving strategic behavior to be accounted for in other variables such as the CHHIA, CBA and ST variables. Serial correlation in the single equation approach is on par with the systems approach.

Multicollinearity between the CBA and CHHIA variables was not detected as the parameters' variance-decomposition proportions were less than 0.50 in both the system and single price equation models. Therefore, the price effects of the common agent and the concentration appear to be separately identified.

6.1. Bidder Concentration Endogeneity

The identification restrictions on each equation appear to be valid *post* estimation. Based on the results of the specification test, 2SLS is more consistent and efficient than OLS indicating that price and cumulative concentration are endogenous. Only the 2SLS estimates are reported in table 3 as 3SLS was not deemed to be more asymptotically efficient than 2SLS.

Consistent with results from previously cited empirical studies, price and concentration are inversely related – lower (higher) prices are a result of higher (lower) winning-bidder concentration. The estimated price reduction is $0.30/cwt per 1000 increase in concentration.

The negative price impact by CBA and CHHIA is robust to single or system modeling and estimation procedures. The fit of the price equation was not significantly improved by single equation nor weakened by system estimation. The informational updating of the CHHIA results in an estimated 25% lower price impact in both the system and single equation models as compared to the single equation using the *ex post* HHIA. Signs and significance remain unchanged for all variables in the models with the exception of the within auction trend variable.

6.2. Common Agent Price Impacts

The common agent paid significantly lower prices than independent competitors by $2.64/cwt Again, because of the small *rho* and indeterminate Durbin Watson statistic; it appears that bidders focus their bidding efforts on a per unit basis. This result is robust to whether a system or single equation is estimated.

6.3. Hedonics, Market Definition and the 'Declining Price Anomaly'

As expected, cattle characteristics are important determinants of each animal's price and exhibit the expected relationships. Also, bidder preferences for cattle traits are important determinants of bidder concentration. Though principal bidders prefer various classifications of cattle, if there is no competitive overlap between the bidders at auction, then the concentration measure would provide little explanatory power in the price equation. Therefore, the product market consisting of cull cows appears to be well defined.

The 'declining price anomaly' observed in the *single* equation models is consistent with that reported by Buccola (1982) and Fatima et al. (2005). However, the *system* results indicate that the total partial impact of trend on prices $\frac{\partial SP}{\partial ST} = \frac{\partial SP}{\partial CHHI}\frac{\partial CHHI}{\partial ST}$ is positive. Assuming the heterogeneity in cattle characteristics are adequately accounted for, then the units are essentially *identical*. What remains is the change in price due to any changes in concentration, which we argue is a result of strategic behavior. As was found, the level of concentration significantly decreases rather than increases throughout the auctions. It is conceivable that the common agent has established himself as a price leader. As such, it would not be in his best interest to reveal his value information early in the auction game. This result is consistent with the 'increasing price anomaly' theory developed by Weber (1983).

7. Conclusions

The primary purpose of this study was to estimate the price impacts of a common bidding agent in a repeated common value English auction setting. We find that the common bidding agent was able to purchase roughly 74 percent of the market and pay approximately 8 percent lower prices than independent bidders. As a whole, our results support the claims from both sellers and buyers and are further supported by auction theory. Sellers claim that common agents reduced competition. Buyers claim that hiring a common agent results in efficiencies from reduced transactions costs. According to theory, efficiency gains by hiring a common agent result in asymmetric bidders in the sense that one of the bidders has a value advantage. In the presence of an advantaged bidder, *almost common value* auction theory predicts that the advantaged bidder is able to purchase more units at lower prices than their rivals (Rose and Kagel, 2008; Klemperer, 1998; Bikhchandani, 1988). From the available data, however, we cannot confirm that the collaborating principals were truly cost advantaged from hiring the common agent; on the other hand, it is unlikely that the principals would rationally engage the services of a costlier agent.

Our results contradict the experimental findings of Rose and Kagel (2008) where they did not find a significant price impact due to the presence of an advantaged bidder. The results from our study affirm that experienced economic agents outside the laboratory either employ information not present in the laboratory setting or may be sophisticated enough to act in accordance with theoretical equilibrium bidding strategies.

The competitive effects of mergers in common value auctions are not well understood (Froeb and Shor, 2005). Though prices at the auction were significantly below regional prices, formal estimation of the impacts of the common agency *per se* on the aggregate seller surplus is left for future research. From theory and supported by our results, however, there are indications of a reduction in aggregate seller welfare at the auction analyzed. 1) Common agency necessarily reduces the number of bidders (mathematical fact). 2) The reduction in bidders (increased concentration) necessarily reduces *average* prices according to theory and our results. 3) Industry claims that common agency leads to efficiencies. 4) Efficiencies lead to an advantaged bidder according to theory. 5) An advantaged bidder is able to pay less than disadvantaged rivals according to theory and our results. We, therefore, can conclude that it is *highly unlikely* that seller surplus at the auction was enhanced due the presence of the common agent.

Our findings support that a new paradigm should be considered in antitrust regulation when evaluating an efficiency defense for principals hiring a common bidding agent in a common value auction setting. Classic dominant firm theory predicts that competition and welfare are enhanced as firms seek to gain a competitive advantage by employing more efficient technology or providing improved services. Empirical research has demonstrated the procompetitive effects from joint bidding arrangements in common value auctions where bidders share their signal information of their estimated valuations (Campo et al., 2003; Hendricks and Porter, 1992; Hoffman et al., 1991). Common agents, however, do not facilitate increased information as only the common agent is present at the auction to receive a signal of the unit's value. Therefore, common agents do not improve information.

Finally, it is unclear what the impact on market prices would have been if more than one common agent (advantaged bidder) were present. Theory has not addressed this contingency. If efficiencies are gained via common agency then independent rivals must either hire the incumbent common agent or hire their own to remain competitive. If hiring a common agent simultaneously reduces the principals' transaction costs and competition, then it is not surprising that common agency is pervasive in the livestock industry today.

Appendix A

The transition period at the beginning of each auction was determined by the mean ten-period moving average standard deviation of the CHHI across all auction sessions and then compared to each within-auction session ten-period moving standard deviation of the CHHI. The first unit where the within-auction session CHHI ten-period moving average standard deviation equals the overall mean of the ten-period moving average standard deviation marks the transition length for that auction session. The transition length averaged 34 observations or about 15 percent of the units sold at an average auction and 22 observations or about 10 percent for the average auction for the winning bidder concentration and principal concentration calculations. The calculated transition periods were not sensitive to choosing a five-, ten- or fifteen-period moving average standard deviation.

Once the transition period length was determined, an adjusted CHHI is calculated. Within the transition period the CHHI is calculated by giving progressively greater weights to the current auction's CHHI, while giving progressively less weight to the previous auction's overall CHHI. (The CHHI calculated from the entire data series was used for the first auction's starting CHHI measure.) After the transition period is complete, full weight is given to the current auction session's CHHI. The converged value of the CHHI at the end of the auction session is then used in the calculation of the next auction session's transition period CHHI, and so on. Therefore, the CHHI calculation not only allows for within auction variation, but also bridges the information gap in concentration used by the agent buyers.

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Table 1: Market Description and Concentration

Principal /Agent	Number of Head Purchased	Plant Capacity (head/day)[2]	Distance from Auction (miles)	Ave. Price ($/cwt)	Ave. Live Weight Purchased (lbs)	Negative Attribute % of Total Purchases	Holstein % of Total Purchases
Prin1[1]	1832	600	165	26.61	1095.57	42.41	78.54
Prin2[1]	1851	-700-	-311-	36.29	1388.44	7.56	56.94
Prin3[1]	1852	1500	109	34.52	1294.10	2.81	88.39
Prin4[1]	158	1200	194	32.32	1180.57	6.33	78.48
Prin5	627	750	185	40.77	1602.64	2.39	75.92
Prin6	610	-100-	-224-	34.82	1256.38	7.21	76.39
Prin7	169	900	185	35.96	1315.75	2.37	91.72
Prin8	164		60	36.83	1220.61	8.54	76.22
Prin9	149		60	36.41	1188.56	7.38	93.29
Other	310		60	35.44	1217.81	11.61	65.16
Aggregate	7722			33.71	1283.18	14.28	75.33
CBA	5693			32.49	1257.74	17.20	74.72
IBAs	2029			37.13	1354.56	6.11	77.03
Prin10	0	700	297	0	0	0	0
HHIA	5593						
HHI_{fringe}	2281						
HHIP	1971						
HHIprocessor[3]	3631	2801					
HHIprocessor[4]	2303	2227					
HHIprocessor[5]		1888					

[1]Collaboration of principals represented by common agent- Principal 1 and 4 are packing plants owned by the same firm.
[2] Derived from the Nalivka (2007). - # - represent suspected processor outlets.
[3]Includes *participating* processor competitors within 200 miles, coupling Prin1and Prin4 market share.
[4]Includes Prin2 and Prin6 *suspected* processor competitors within 300 miles, coupling Prin1and Prin4 market share.
[5]Includes all *potential* processor competitors within 300 miles, coupling Prin1 and Prin4 market share.

Table 2: Descriptive Statistics of Data and Calculated Variables

Variable	Mean	Standard Deviation	Minimum	Maximum	Frequency	Percent of Total
SP	33.71	5.85	5	50		
CV	79.89	3.19	75.50	86.20		
L1SP	33.71/ 33.71	4.49/ 4.48	14.88/ 14.90	46.35/ 46.10		
CBA					5693	73.72
HC					5817	75.33
Neg					1103	14.28
Wt	1283.18	220.77	480	2160		
ST	227.12	55.73	93	334		
Number Winning Bidders	6.44	0.66	5	7		
$CBA_{MarketShare}$	73.64	5.57	61.94	86.15		
$Prin5_{MarketShare}$	8.02	9.71	17.91	59.74		
$Prin6_{MarketShare}$	8.11	12.24	0	59.32		
$Prin7_{MarketShare}$	2.26	8.55	0	38.71		
$Prin8_{MarketShare}$	2.09	4.92	0	22.22		
$Prin9_{MarketShare}$	1.93	7.43	0	37.04		
$Other_{MarketShare}$	3.95	9.37	1.23	32		
CHHIA	5677.20	785.12	3735.15	8383.74		
CHHIP	2160.01	280.20	1551.01	3956.69		
L1CHHIA	5677.26	782.11	3769.52	8358.74		
L1CHHIP	2159.97	274.80	1545.25	3923.37		

Table 3: Estimated System of Equations

Regressors	Selling Price 2SLS (std.err.)	CHHIA 2SLS (std.err.)
Intercept	-14.99* (3.81)	6124.66* (452.60)
SP		
L1SP	0.09* (0.01)	
CHHIA	**-0.0003*** (0.00006) [3]	
L1CHHIA		0.06* (0.01)
CBA	**-2.64*** (0.10) [3]	
CV	0.29* (0.03)	
HC	-1.93* (0.10)	-2.69* (2.20)
NEG	-7.25* (0.13)	-12.32* (2.66)
WT	0.05* (0.01)	0.09* (0.03)
WT^2	-0.00002* (6.1E-6)	-0.00004* (0.00001)
WT^3	5.5E-9* (1.5E-9)	
ST	-0.001 (0.0006)	-3.33* (0.53)
T	-0.00009* (0.00004)	-0.04 (0.10)
Hausman's Specification Test	OLS v. 2SLS: m = 32.59* OLS v. 3SLS: m = -358 OLS v. SUR: m = -1418 3SLS v. 2SLS: m = 1256*	
R^2	0.59	0.98
Rho	-0.09[1]	-0.34[1]
Durbin-Watson	1.81[1]	1.33

* Reject null at $\alpha = 0.01$.

[1] Rho and Durbin-Watson were calculated during the second-stage before implementing the AR1 process in the system.

[2] Though D-W is in the indeterminate region of the Durbin-Watson statistic, estimates reported are corrected for first-order autocorrelation. No discernable differences were observed in the standard errors with or without correction.

[3] The final condition index is 1162 > 30. Parameters with variance-decomposition proportions greater than 0.50 were the polynomial values of live weight in the price equation. The second to last condition index is 191 > 30. Parameters with variance-decomposition proportions greater than 0.50 were the CV and T.

Table 4: HHIA vs CHHIA: Estimated Coefficients and (Standard errors)

Regressors	Selling Price OLS (std.err.)	Selling Price OLS (std.err.)
Intercept	-15.82* (3.79)	-15.07* (3.81)
L1SP	0.09* (0.01)	0.09* (0.01)
HHIA	**-0.0004*** (0.0001)	
CHHIA		**-0.0003*** (0.0001)
CBA	**-2.66*** (0.10)	**-2.65*** (0.10)
CV	0.30* (0.03)	0.29* (0.03)
HC	-1.95* (0.10)	-1.93* (0.10)
NEG	-7.25* (0.13)	-7.25* (0.13)
WT	0.04* (0.01)	0.05* (0.01)
WT^2	-0.00002* (6.1E-6)	-0.00002* (6.1E-6)
WT^3	5.5E-9* (1.5E-9)	5.5E-9* (1.5E-9)
ST	-0.001 (0.001)	-0.001 (0.001)
T	-0.0001* (0.00003)	-0.0001* (0.00003)
R^2	0.59	0.59
Rho	-0.09	-0.09
Durbin-Watson	1.81[1]	1.81[1]

*Significantly different from zero, $\alpha = 0.01$.

[1]Though D-W is in the indeterminate region of the Durbin-Watson statistic, estimates reported are corrected for first-order autocorrelation. No discernable differences were observed in the standard errors with or without correction.

[2]The final condition index is 1163 for both equations. Parameters with variance-decomposition proportions greater than 0.50 were the polynomial values of live weight.

Figure 1: Weekly Average Price Comparison

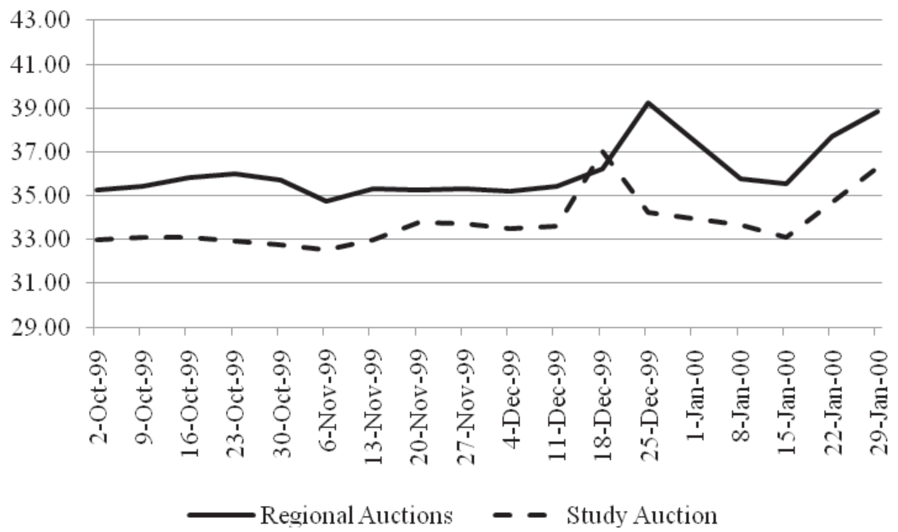


Figure 2: Example Transition Period Determination – October 4, 6 and 11 Sales

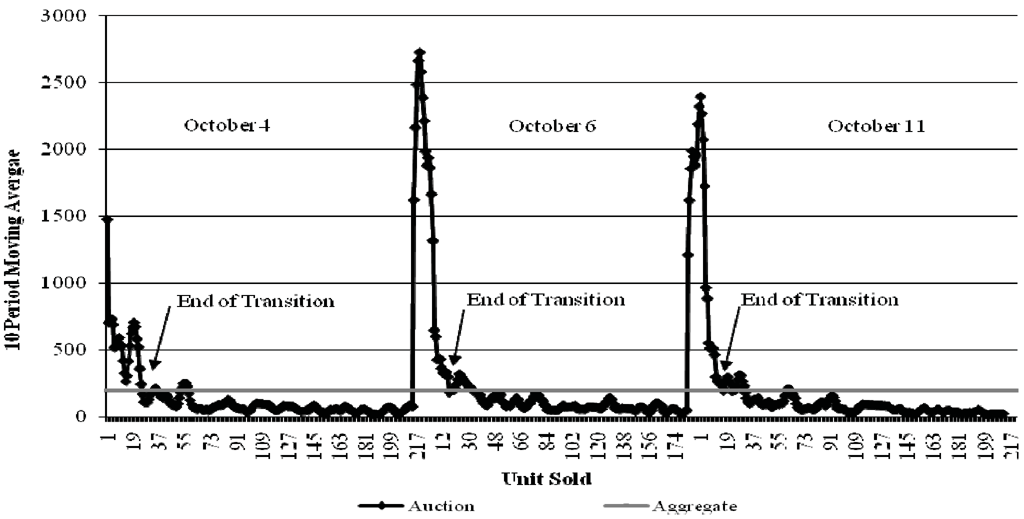
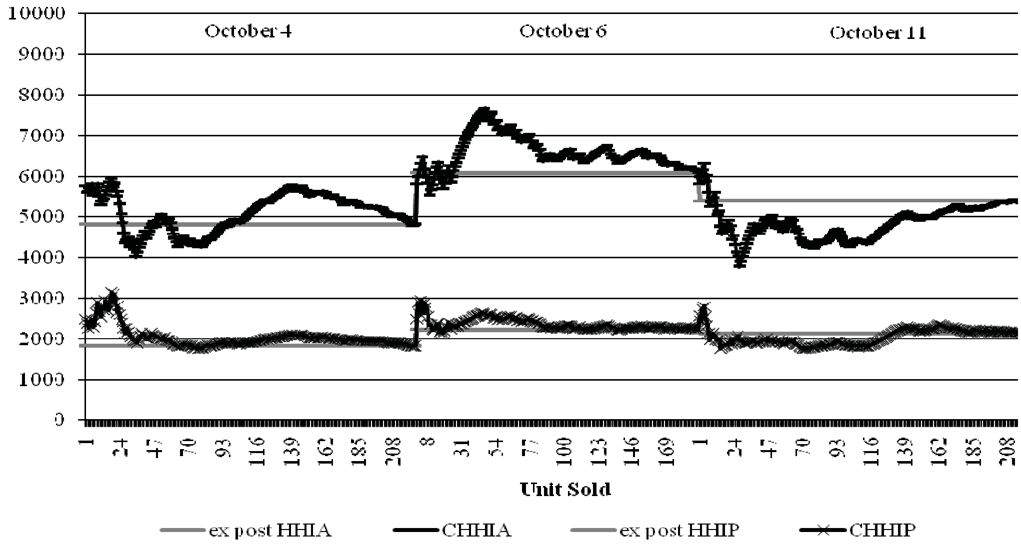


Figure 3: Example CHHI for Agents and Principals – October 4, 6 and 11 Sales



Endnotes

[1] In response to seller's concerns, the United Stated Department of Agriculture, Grain Inspection Packers and Stockyards Administration has recently proposed a new regulation intended to prohibit slaughtering firms (processors) from hiring common bidding agents (USDA, GIPSA, 2010).

[2] It has also been shown in the independent private value setting that bidders with 'synergies' or cost complementarities across multiple units sold will bid aggressively (e.g. Jeitschko and Wolfstetter 2002; De Silva et. al. 2005; Leufkens et. al. 2010). However, this literature does not predict that aggressive bidding results in reduced competition as in the common value setting.

[3] Since the USDA does not make public detailed purchasing statistics for the commission order-buyers and dealers they regulate, we support this claim from interviews with cattle buyers, packers, auction owners and USDA officials.

[4] Due to a confidentiality agreement with the auction company that supplied the data and the requirements of confidentiality by the then GIPSA's lead investigator and now the lead author of this research, the names and locations of the principals and agents involved cannot be disclosed. The data as presented, however, are available upon request.

[5] Weekly regional cull cow prices were collected from the Wisconsin State Livestock and Seed Division. Data are available upon request. These regional data include a sample of the prices from the market analyzed in this study. Therefore, mean differences in prices are biased downward. Due to the Student's $t = -5.30$, we reject the null at $\alpha = .01$ that average prices at the auction equal average prices within the region.

[6] The primary negative attributes noted by the auctioneer were lameness, dullness of character, lump jaw, Cesarean and cancer eye, all of which lower the expected red meat yield of the animal.

[7] For a detailed discussion of the guidelines used by antitrust authorities for defining the relevant market and identifying the competitors see the 2010 Horizontal Merger Guidelines and the Antitrust Guidelines for Collaborations Among Competitors 2000.

[8] In *Hennessey* (*Hennessey*, 57 Agric.Dec. 1432 (1998)), the relevant product market was separated within classifications of cull cows by quality or type, while the geographic market was defined to include a single auction market location, as most cull cows are hauled short distances (50 to 75 miles). However, other judicial findings related to cattle have not allowed product lines to be drawn on quality classifications because quality is not a well definable market (*Monfort of Colorado v. Cargill, Inc*., 591 F. Supp. 683, 706 (D. Colo. 1983), aff'd, 761 F.2d 570 (10th Cir.1985), judgment rev'd, 479 U.S. 104 (1986)). Geographic sub-markets for primary producers of agricultural products have also been defined as a single delivery point (*U.S. v. Cargill, Inc*., 2000 WL 1475752, 2000-2 Trade Cases P 72,966, Comm. Fut. L. Rep. P 28,212 (D.D.C. Jun 30, 2000) (NO. CIV. A. 991875GK). Although bidders/principals in our study appear to prefer different mixtures of input live animal physiological characteristics, we too argue that the relevant market is generally defined as cull cows at a single auction location.

[9] According to the 2010 Horizontal Merger Guidelines (p. 19), an HHI that exceeds 2500 is considered a highly concentrated industry.

[10] In accordance to Antitrust Guidelines for Collaborations Among Competitors, 2000 a buyer collaboration is essentially a 'merger-in-part'. According to the 2010 Horizontal Merger Guidelines (p. 19), when the post-merger HHI exceeds 2500, it will be presumed that mergers producing an increase in the HHI of more than 200 points are likely to create or enhance market power or facilitate its exercise.

[11] Nonparametric estimation is the preferred structural estimation method of bidding functions, but this method has not been developed to account for the unknown stochastic nature of common value auctions, especially in English auctions (Paarsch and Hong, 2006; Athey and Haile, 2002; Laffont and Vuong ,1996). Therefore, no empirically identifiable bidding structure can be imposed on our data.

[12] The description of packer buying practices is provided from interviews with the auction company that supplied the data, bidders at the auction analyzed and various packer processors.

[13] Pooled t-tests verify that the mean CHHIA for the common agent of 5750 is statistically different than the mean for independent purchasers of 5470 at $\alpha = 0.01$.

[14] Ward et al. (1998) use the previous day's carcass value. However, from conversations with industry participants processors commit a significant portion of their capacity in advance of production. Since it is unknown when the prices reported on any given day will be relevant to live animals being purchased and the previous results were not sensitive to the timing assumption, we use the current day's carcass value.

[15] Weber concludes that prices will rise because bidders do not want to reveal information about their valuation early in the game and thus bid more conservatively for units early in

the auction. Weber and Fatima et al. argue that, since bidders expect the number of bidders to be reduced over the course of the auction, each unit in previous succession is discounted by the option value of winning the next unit, but not to the degree that eliminates declining prices.