Dynamic Assessment of Bertrand Oligopsony in the U.S. Cattle Procurement Market

In Bae Ji
Researcher
Korea Rural Economic Institute
Seoul, Korea

Chanjin Chung
Professor
Oklahoma State University

Contact: Chanjin Chung
Department of Agricultural Economics, 322 Ag Hall
Oklahoma State University
Stillwater, OK 74078
Phone: 405-744-6164
Fax: 405-744-8210
chanjin.chung@okstate.edu

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011

Abstract

The new empirical industrial organization approach with the Bertrand model is employed to measure the oligopsony market power in the U.S. cattle procurement market. The assumption of price competition (Bertrand model) based on the nature of cattle production such as cattle cycle and seasonality is used and compared to quantity competition (Cournot model). The empirical results show that the oligopsony market power exists in the U.S. cattle procurement market. The cattle cycle and seasonality affect the oligopsony market power and the cattle cycle causes the change of market power. However, concentration has a negative effect on the oligopsony market power.

Keywords: cattle cycle, concentration, market power, NEIO, oligopsony, seasonality

Dynamic Assessment of Bertrand Oligopsony in the U.S. Cattle Procurement Market

Introduction

Most studies using the new empirical industrial organization (NEIO) approach on the market power of the U.S. beef packing industry focus on the market structure, such as horizontal concentration and vertical integration, as sources of market power rather than characteristics of the market such as cattle cycle and seasonality. Also, the studies generally use the Cournot model by assuming quantity competition in the cattle procurement market.

Cattle production fluctuates unpredictably based on weather conditions and economic environment while beef demand is relatively stable and predictable. The fluctuation of cattle production leads to price fluctuation and these variations could influence the bargaining position of producers and packers in the cattle procurement market (Crespi, Xia, and Jones 2010). Therefore, the periodic fluctuation of the cattle production, cattle cycle and seasonality, could affect market power in the cattle procurement market. In addition, this fluctuation in cattle supply could make packers compete with price rather than quantity.

In the long-run, packers make significant production decisions based on quantity such as increasing factory size, purchasing slaughter machines or packing machines, as well as other investments. These decisions could lead to quantity competition. However, in the short-run, cattle purchase could lead to price competition (Lepore 2008). Under the condition of fixed plant capacity, if packers' cattle amount is not guaranteed in the cattle market during the short cattle supply then they would aggressively bid to obtain their optimal operation level of cattle for beef production. On the other hand, if there is enough cattle supply in the market, then packers might try to lower the cattle price under the marginal cost for cattle production. This strategy for packers is consistent with the structural conduct performance (SCP) theory (Stiegert, Azzam, and Brorsen 1993). Additionally, the reason why packers gradually increase the volume of alternative marketing arrangements (captive supply) could be explained by this view point. Packers can reduce cattle supply risk and price competition by increasing captive supply during the short cattle supply and they might be tacitly collusive to lower the cattle price during the excess cattle supply. From this perspective, the cattle cycle and seasonality may affect pricing and market power in the cattle market. It therefore stands to reason that the Bertrand model is more accurate than the Cournot model to measure the oligopsony market power for the cattle procurement market.

The objective of this paper is three fold. First, this paper provides a conceptual framework for the Bertrand model to analyze oligopsony market power and to compare the Bertrand model with the Cournot model. Second, this paper estimates the overall market power with the static model and annual market power changes with the dynamic model at national and two regional levels. Finally, the effects of concentration, cattle cycle, and seasonality on markdown for cattle price are estimated to look into how they influence on market power in the U.S. cattle procurement market.

The empirical results show that oligopsony market power exists in the cattle procurement market and that oligopsony market power is affected by cattle cycle and seasonality and, finally, that the variation of market power changes equivalently with the cattle cycle. However, concentration has a negative effect on market power in the cattle procurement market.

Concentration, Cattle cycle, and Seasonality

The concentration for cattle procurement was drastically increased during the 1980's and has stayed at high levels after 1990 (USDA). Figure 1 shows the concentration change based on Herfindahl-Hirschman Index (HHI) for steer and heifer slaughter. The HHI was 0.0561 in 1980 but it was rapidly increased by 0.2005 in 1992, and has stayed around 0.2 until recently. The Department of Justice consider the industry to be concentrated if the HHI is greater than 0.18. Therefore, concentration has been in the middle of controversy for the market power issue in the cattle procurement market during the last three decades.

Cattle cycles are measured from one trough to the next. There are six full cycles in cattle inventories since 1928 and the average length of cattle cycles are about 10 years (Anderson, Robb, and Mintert 1996). Figure 2 shows the cattle cycle based on cattle supply from 1980 to 2009. The fifth cycle began in 1979 and the sixth cycle began in 1990. The latest cycle began in 2004 and cattle supplies show an increasing trend.

A seasonal pattern is a regularly repeating cycle that is completed once every twelve months. Figure 2 shows the averaged monthly changes of the slaughtered cattle supply from 1980 to 2009. The slaughtered cattle quantities are high from May to October while those from November to April are low. These cattle cycle and seasonality cycles are responsible for creating price fluctuation in the cattle market.

Literature review

Most studies using NEIO approach use the Cournot model to analyze market power for the U.S. beef packing industry because it is easy to parameterize the conjectural elasticity, price elasticity of demand, and price elasticity of supply using simultaneous equations. Additionally, those elasticities can be used to easily calculate market power (Schroeter 1988; Azzam and Schroeter 1995; Azzam 1997; Sexton 2000; Lopez, Azzam and Espana 2002; Tostao and Chung 2005; Zheng and Vukina 2009).

There are three studies that use the Bertrand oligopsony model for the cattle market (Koontz, Garcia, and Hudson 1993; Koontz and Garcia 1997; Cai, Stiegert, and Koontz 2009). They develop the Regime-Switching model based on the dynamic non-cooperative game theoretic model. They find that the evidence of cooperative/competitive conduct among the beef packers is present, but the conduct varies across markets. They attempt to determine whether the cooperative conduct is present as evidence of market power, but they don't estimate the conduct parameters in the cattle procurement market.

Two studies are concerned with cattle supply and cattle cycle. Stiegert, Azzam, and Brorsen (1993) use the NEIO model assuming quantity competition to determine the effect of anticipated and unanticipated cattle supply on the departure of fed cattle prices from cattle's marginal value product. They find that packers follow an average processing cost (APC) pricing rule and that reducing concentration is unlikely to affect change in cattle prices predicted by SCP based studies of the industry[1]. They use anticipated and

[1] Average processing cost (APC) pricing is that packers establish a cattle bid price by subtracting the average processing cost from the price received for carcasses or boxed beef while the structure-conduct-performance (SCP) paradigm theory suggests that the markdown will respond to supply changes, but in a direction

unanticipated cattle supply to look into packer's behavior, primarily how packers react to those cattle supplies. The anticipated cattle supply is specified by the cattle on feed, cattle placements, and the seasonal dummy variable. Therefore, the effects of cattle cycle and seasonality are embedded in the anticipated cattle supply. Consequently, they do not explain the effects of cattle cycle and seasonality. Crespi, Xia and Jones (2010) investigate the relationship between market power and cattle cycle with a dynamic cattle production decision model and a dynamic profit maximization model based on the Cournot model. They provide a conceptual framework for how the cattle cycle and buyer markets are related. They find that a larger cattle stock leads to a lower fed cattle price and the cattle stock's negative effect on price is magnified by the degree of buyer market power. They develop an equilibrium model that consists of the dynamic cattle supply equation for feeders and dynamic cattle demand for packers. However, they assume that the market power is determined by the number of packers rather than the packer's market conducts.

Therefore, this paper extends the traditional NEIO model in two ways. First, this paper provides how the implications of market power from the Bertrand model differ compared to the Cournot model through analytical derivation. Second, concentration in the traditional view as well as cattle cycle and seasonality for the nature of cattle market are included in modeling the market conduct equation in order to measure their effects on market power.

---

opposite to that of APC pricing. That is, as anticipated supply declines, packers bid more aggressive while anticipated supply is abundant, bidding becomes less aggressively and the markdown increases (Stiegert, Azzam, and Brorsen 1993).

The Model

The two NEIO models are reviewed in this section: the Bertrand model and the Cournot model. We analyze the input market rather than output market, so we use monopsony or oligopsony as working terms instead of monopoly or oligopoly. In the Bertrand oligopsony model, buyers choose the price to pay for a unit of input, which affects the market supply. The Bertrand model predicts that a duopsony is enough to push prices up to the marginal cost level for input production. This suggests that duopsony will result in perfect competition, commonly referred to in the economics literature as the “Bertrand paradox”. However, in the Cournot oligopsony model, where buyers compete strategically with their quantity, buyers enjoy positive profits as the resulting input market prices do not exceed those of the marginal costs. By imposing some assumptions in the modeling, we will demonstrate how this suggestion that duopsony will result in perfect competition in the Bertrand model could be changed.

Bertrand Model

In view of the intended application, we will focus on oligopsony market power in the cattle procurement market. Packers determine cattle price as a strategy variable to maximize their profit from the cattle procurement market while the wholesale price to sell their output, boxed beef, to the retailer is assumed as a given. The cattle supply is assumed as fixed in the short-run because feeders cannot increase their cattle supply in the short-run. Feeders cannot determine the cattle supply, but they can sell their cattle to the highest bidder in the cattle market.

In the beef processing industry it is assumed that N packers convert a single farm input, cattle, into a final output, boxed beef, with fixed proportions technology between the farm input and the output (Schroeter 1988; Azzam 1997). Conversion of the farm input into output requires non-farm inputs that are purchased in competitive markets. Profit, π_i, for the i th firm (for $i = 1, 2, \ldots, N$) is:

(1) $$\underset{w_i}{Max} \ \pi_i = (P - w_i) q_i (w_i, w_j(w_i)) - C_i(q_i(w_i, w_j(w_i)), \mathbf{v}),$$

where P is the boxed beef wholesale price, w_i is the cattle input price for i th firm, w_j is the cattle input price for j th firm (for $j = 1, 2, \ldots, N$ and $i \neq j$), q_i is the i th firm's beef product or cattle input, $C_i(q_i, \mathbf{v})$ is the processing cost for the i th firm, and $\mathbf{v}$ is a vector of prices of non-farm inputs. The first order condition for profit maximization is:

(2) $$\frac{\partial \pi_i}{\partial w_i} = -q_i + (P - w_i)\left(\frac{\partial q_i}{\partial w_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial w_j} \frac{\partial w_j}{\partial w_i} \right) - \frac{\partial C}{\partial q_i}\left(\frac{\partial q_i}{\partial w_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial w_j} \frac{\partial w_j}{\partial w_i} \right) = 0.$$

Rearranging the first order condition and re-writing in elasticity form yields:

(3) $$q_i = (P - w_i - mc_i)\left(\varepsilon_{ii} \frac{q_i}{w_i} + \sum_{j \neq i} \varepsilon_{ij} \theta_{ji} \frac{q_i}{w_i} \right),$$

where $\varepsilon_{ii} = \frac{\partial q_i}{\partial w_i} \frac{w_i}{q_i}$ is the own price elasticity of cattle purchase for the i th firm,

$\varepsilon_{ij} = \frac{\partial q_i}{\partial w_j} \frac{w_j}{q_i}$ is the cross price elasticity for the i th firm with respect to the j th firm's price changes, $\theta_{ji} = \dfrac{\partial w_j}{\partial w_i}\dfrac{w_i}{w_j}$ is the price conjectural elasticity of j th firm with respect to i th firm's price change, and $mc_i = \dfrac{\partial C(q_i, \mathbf{v})}{\partial q_i}$ is the i th firm's marginal cost.

If we assume that the effect of the j th firm's price change on the i th firm's fed cattle purchase is smaller than the effect of its own price change, and firms are symmetric (Cai, Stiegert, and Koontz 2009), this means $\dfrac{\partial q_i}{\partial w_i}\dfrac{w_i}{q_i} > -\dfrac{\partial q_i}{\partial w_j}\dfrac{w_j}{q_i}$ and then we can write the ratio of own price elasticity of cattle procurement to cross price elasticity with respect to j th firm's price, as $R_i = -\left(\dfrac{\partial q_i}{\partial w_i}\dfrac{w_i}{q_i} \Big/ \dfrac{\partial q_i}{\partial w_j}\dfrac{w_j}{q_i}\right) \geq 1$. That is, $\varepsilon_{ij} = -\dfrac{\varepsilon_{ii}}{R_i}$, then the equation (3) becomes:

(4)
$$P - w_i = \frac{w_i}{\left(1 - \frac{\Theta_i}{R_i}\right)\varepsilon_{ii}} + mc_i,$$

where $\Theta_i = \sum_{j \neq i} \theta_{ji}$. In equilibrium, all firms have the same value Θ_i, R_i and ε_{ii}, then the industry level margin equation can be yield (Appelbaum 1982; Schroeter 1988):

(5)
$$P - W = \frac{1}{\left(1 - \frac{\Theta}{R}\right)\varepsilon_b} W + mc,$$

where W is the industrial level cattle price, Θ is the industrial level price conjectural elasticity, R is the industrial level ratio of own price elasticity of cattle procurement to cross price elasticity, ε_b is the own price elasticity of cattle purchase, and mc is the industrial level marginal cost.

In equation (5), the term in the left side is the industrial level margin for a unit of cattle, the first term on the right side is markdown for a unit of cattle in the cattle procurement market, and the second term on the right side is the marginal cost for a unit of cattle in the beef processing industry. For analyzing the short-run oligopsony power in the cattle procurement market we should look at the markdown term. The markdown is determined by three parameters: the price conjectural elasticity, the ratio of own price elasticity of cattle procurement to cross price elasticity, and the own price elasticity of cattle purchase. These three parameters show the market participant's reactions about a firm's cattle pricing change. That is, the price conjectural elasticity shows the reaction of the rival's cattle pricing, the ratio of own price elasticity of cattle procurement to cross price elasticity shows the relative effect firms' price change on a firm's cattle purchase, and the own price elasticity of cattle purchase reveals the decision of the feeder's cattle supply decision to choose who they sell their cattle to, corresponding to a firm's pricing change.

The own price elasticity of cattle purchase, ε_b, is an infinite in the traditional view of the Bertrand model so that the market will reflect perfect competition with no markdown in the industry.[2] In reality, however, there are some restrictions like capacity constraints. If a single firm does not have the capacity to procure the whole cattle market then the "price

[2] The Bertrand model rests on the following assumptions: 1) There are at least two firms producing homogeneous (undifferentiated) products; 2) Firms do not cooperate; 3) Firms compete by setting prices simultaneously; 4) Consumers buy everything from a firm with a lower price. If all firms charge the same price, consumers randomly select among them (Bertrand 1883). The fourth assumption represents that the own price elasticity is infinite.

equals marginal cost" result may not hold. Thus, the range of the own price elasticity of cattle purchase will be $0 < \varepsilon_b < \infty$. This reflects that the "Bertrand paradox" can be fixed if the own price elasticity of cattle purchase is quite smaller than the infinite. The own price elasticity of cattle purchase is usually greater than the price elasticity of cattle supply, $\varepsilon_c = \frac{\partial Q}{\partial W}\frac{W}{Q}$ (Anderson, Palma, and Kreider 2001).

For the market conduct in equation (5), when $\varepsilon_b = \infty$, the market will be perfect competition. When $0 < \varepsilon_b < \infty$, the market will be oligopsony or monopsony. Under this assumption, $0 < \varepsilon_b < \infty$, market conduct depends on the price conjectural elasticity, Θ. $\Theta = 0$ means Bertrand-Nash when $N > 1$ and pure monopsony when $N = 1$. $\Theta = 1$ means cartel or symmetry among the firms and $0 < \Theta < R$ means oligopsony.[3]

Cournot Model

Alternatively, in the Cournot model packers determine cattle quantities as a strategy variable to procure the cattle from the cattle procurement market and feeders determine the cattle supply to the cattle procurement market. Finally, cattle price is determined in the market by cattle supply and demand. That is, the fixed supply assumption is released by long-run decision making for feeders and the feeders face a competitive market for selling their cattle to packers. Under the same assumption of the fixed proportions technology, then i th firm's profit is:

[3] Koontz, Garcia, and Hudson (1993) interpret the value of $\Theta = 0$ means packers display non-cooperative pricing and the value of $\Theta > 0$ means packers have cooperative pricing in the cattle procurement market.

(6) $$\underset{q_i}{Max}\ \pi_i = \left(P - W(Q)\right)q_i - C_i(q_i, \mathbf{v}),$$

where P is the beef wholesale price, W is the cattle price in the market level, and q_i is the i th firm's cattle or boxed beef quantity. The first order condition for profit maximization is:

(7) $$\frac{\partial \pi_i}{\partial q_i} = P - W - \frac{\partial W}{\partial Q}\frac{\partial Q}{\partial q_i} q_i - \frac{\partial C_i(q_i, \mathbf{v})}{\partial q_i} = 0.$$

Rearranging the first order condition and re-writing in elasticity form yields:

(8) $$P - W = \frac{\phi_i}{\varepsilon_c} W + mc_i,$$

where $\phi_i = \frac{\partial Q}{\partial q_i}\frac{q_i}{Q}$, is the i th firm's quantity conjectural elasticity and $\varepsilon_c = \frac{\partial Q}{\partial W}\frac{W}{Q}$ is the price elasticity of cattle supply in the cattle procurement market. In equilibrium, all firms have the same value ϕ_i, then the industry level margin equation can be written (Appelbaum 1982; Schroeter 1988):

(9) $$P - W = \frac{\Phi}{\varepsilon_c} W + mc.$$

In the Cournot model, markdown consists of the quantity conjectural elasticity, Φ, and the cattle supply elasticity, ε_c. The range of conjectural elasticity is between 0 and 1. The value $\Phi = 0$ means perfect competition and $\Phi = 1$ means pure monopsony, and other values mean various degrees of oligopsony power with higher values of Φ denoting greater oligopsony (Appelbaum 1982). The price elasticity of cattle supply, ε_c, is considered as $0 < \varepsilon_c < 1$ because price elasticity of supply for agricultural markets are usually inelastic and positive.

Empirical procedures

For econometric estimation, we assume a generalized Leontief cost function (Diewert 1974; Schroeter 1988) for the beef processing industry:

(10) $$C(Q, \mathbf{v}) = Q\sum_k \sum_j \alpha_{kj}(v_k v_j)^{1/2} + \sum_j \beta_j v_j ,$$

where v_j and v_k are the input price of labor, capital, and material. Then the industrial level marginal processing cost function is given by:

(11) $$mc = \sum_k \sum_j \alpha_{kj}(v_k v_j)^{1/2} ,$$

by substituting equation (11) into equation (5), we obtain the industrial level Bertrand margin equation:

(12) $$P - W = \frac{1}{\left(1 - \frac{\Theta}{R}\right)\varepsilon_b} W + \sum_k \sum_j \alpha_{kj}(v_k v_j)^{1/2} + e_b ,$$

where $\frac{1}{(1-\Theta/R)\varepsilon_b}$ is the industry-wide markdown in cattle prices from cattle's marginal value and e_b is the error term for the Bertrand margin equation respectively. However, the parameters in the industry-wide markdown cannot be estimated because of limitation of firm level data. Consequently, we estimate the whole part of the industry-wide markdown, $M = \frac{1}{(1-\Theta/R)\varepsilon_b}$, as follow:

$$P - W = M \cdot W + \sum_k \sum_j \alpha_{kj} (v_k v_j)^{1/2} + e_b \,. \tag{13}$$

To estimate the margin equations (13), simultaneous equations are needed such as three non-farm input demand equations. Non-farm input demands are obtained by applying Shephard's lemma on the industry level processing cost function represented by equation (10) as:

$$\frac{\partial C(Q, \mathbf{v})}{\partial v_j} = X_j = Q \sum_k \alpha_{kj} \left(\frac{v_k}{v_j} \right)^{1/2} + \beta_j \,, \tag{14}$$

which can be re-arranged as:

$$\frac{X_j}{Q} = \sum_k \alpha_{kj} \left(\frac{v_k}{v_j} \right)^{1/2} + \frac{\beta_j}{Q} + e_j \,, \tag{15}$$

where X_j is the industry level derived non-farm input demand for labor, capital, and material, X_j / Q is the inverse of productivity for each non-farm input, and e_j is the error term for the non-farm input demand equation respectively.

Finally, to analyze the effect of concentration, cattle cycle, and seasonality on the cattle price, we make the markdown as a function of these variables. This specification also allows the dynamic estimation of the market conduct over time. The industry-wide markdown M is specified as:

$$M = \gamma_0 + \gamma_1 H + \gamma_2 C + \gamma_3 D_1 + \gamma_4 D_2 + \gamma_5 D_3 \,, \tag{16}$$

where H is the Herfindahl-Hirschman Index, C is the cattle cycle, and D_i with $i = 1, 2, 3$ are seasonal dummy variables, and γ 's are parameters. In order to generate cattle cycle variability, the following yearly cattle supply equation is estimated:

(17) $$Q = \delta_0 + \delta_1 time + \varepsilon_q ,$$

and the cattle cycle variable, $C = Q - \hat{Q}$, is calculated for each year. If equation (16) substitutes into equation (13), then dynamic equation can be written as:

(18) $$P - W = (\gamma_0 + \gamma_1 H + \gamma_2 C + \gamma_3 D_1 + \gamma_4 D_2 + \gamma_5 D_3) \cdot W + \sum_k \sum_j \alpha_{kj} (v_k v_j)^{1/2} + e_d .$$

We utilize two systems: the static model and the dynamic model for three regions: National, Nebraska, and Texas. Equations (13) and (15) constitute a system of four equations for the static model and equations (18) and (15) constitute a system of four equations for the dynamic model. We use the generalized method of moment (GMM) which employs instrumental variable estimators since the system equations have endogeneity problems. GMM also provides a consistent estimator when heteroskedasticity and autocorrelation are present (Breusch 1978; Godfrey 1978). The eighteen instrumental variables included in the equation are Herfindahl-Hirschman Index (HHI) for the steer and heifer slaughter, 5 market steer weighted price, Nebraska steer and heifer weighted price, Texas steer and heifer weighted price, labor price, capital price, material price, cattle on feed, cattle placement, cattle on marketing, disappearance, cycle, seasonal dummy variables, time, and squared time. The industry-wide markdown rates as market power indices and markdowns in cattle prices from cattle's marginal value for each year are also estimated through GMM using the MODEL Procedure in SAS 9.2.

The first null hypothesis is that oligopsony market power in the U.S. cattle procurement market equal zero. Rejecting it suggests that packers exert oligopsony market power in the U.S. cattle procurement market. The second null hypothesis is that the concentration, the cattle cycle, and the seasonality have no effect on the oligopsony market power. Rejecting it suggests that the concentration, the cattle cycle, and the seasonality might be used as a way to price under the marginal cost for cattle production.

Data

In this paper, we use monthly data series for the U.S. cattle procurement market ranging from 1980 to 2009. As National, Nebraska, and Texas cattle supplies, the steer and heifer slaughter total live weights for National level, for Nebraska region, and Texas region are from Livestock Slaughter Annual Summary of United States Department of Agriculture (USDA). The wholesale price and the 5 market steer weighted price data are from the beef value and price spread monthly data sets from the USDA Economic Research Service (ERS). The wholesale price is modified by including by-product value and by dividing with 2.4 as conversion factor to a unit of live cattle (USDA). The steer and heifer weighted prices data for Nebraska and Texas are compiled from USDA Agricultural Marketing Service (AMS) data. The producer price index for farm products slaughter steer and heifer is from Bureau Labor Statistics (BLS). The price index and the productivity index of labor, capital, and material for U.S. food and other industries are obtained from the Major Sector Multifactor Productivity Index Database of BLS. The cattle on feed, the cattle placement, the cattle on marketing, and disappearance data are from the USDA National Agricultural Statistics Service and Red Meats Yearbook of USDA. The Herfindahl-Hirschman Index for the U.S. beef processing industry is the steer and heifer slaughter concentration index compiled from several annual reports from the Packers and Stockyards Statistical Report

(1996-2009). The definitions and descriptive statistics of these variables are presented in table 1.

Results

The estimation results of the static model and the dynamic model for the National level, Nebraska region, and Texas region by GMM are reported in table 2 and 3. All of the 10 parameter estimates in the static model and most parameter estimates in the dynamic model for National, Nebraska, and Texas are statistically significant at the 5% significance level.

With these estimation results and with mean values of cattle prices and input prices, the market power parameters such as market power (industry-wide markdown rate), markdown, and marginal cost are calculated and summarized in table 4. As the key parameter, the market power estimates in the static model are 0.0366, 0.0199, and 0.0138 for National, Nebraska, and Texas respectively while 0.0629, 0.0401, and 0.0377 in the dynamic model. The market power of National is the biggest compared to the two regions and the market power of Nebraska is greater than the market power of Texas. The market power from the dynamic model shows the same results with the static model, but their value is almost twice that of the static models'. The values of 0.0366, 0.0199, and 0.0138 for market power in the static model mean that there are about 3.66 percent, 1.99 percent, and 1.38 percent of markdowns for the cattle price respectively.

For the markdowns and the marginal costs, in the static model, the markdowns are 2.6537, 1.4368, and 1.0039 and the marginal costs are 6.7237, 8.1916, and 8.0956 for National, Nebraska, and Texas respectively and they are all significant at the 5%

significance level. In the dynamic model, the markdowns are 4.5645, 2.8905, and 2.7486 and the marginal costs are 5.3866, 6.9359, and 6.5899 for National, Nebraska, and Texas respectively and they are also all significant at the 5% significance level. The markdown value of 2.6537 and marginal cost of 6.7237 for National in the static model mean that the average markdown for the cattle price is $ 2.65/cwt and the marginal cost of cattle slaughter is $ 6.72/cwt, respectively. These results of market power and markdown for Nebraska and Texas in the static model are similar to the results of Schroeter (1988) and Stiegert, Azzam, and Brorsen (1993) while the results for National and dynamic model are slightly bigger than their results.

The dynamic model shows the effect of concentration, cattle cycle, and seasonality. The parameters of concentration, cattle cycle, and three seasonal variables for National are -0.2491, 0.0082, -0.0122, 0.0169, and 0.0085 respectively. They are all significant at the 5% significance level. Nebraska and Texas also show similar estimation results. These results signify that concentration has a negative impact on the cattle price markdown. That is, the markdown in cattle price is decreased by increasing the concentration. This result coincides with a majority of results from similar studies (Azzam 1997; Stiegert, Azzam, and Brorsen 1993). The parameters of cattle cycle and seasonality for May-July and Aug-Oct are positive while the parameter of seasonality for Feb-Apr is negative. This result means that when the cattle supply is greater than the normal trends (or expected supply), packers exercise more market power in the cattle procurement market and vice versa. This result supports the view of SCP that when the cattle supply is inflated the packers tacitly collude to drop the cattle price. When the cattle supply is short the packers bid aggressively to get some amount of cattle in the cash market.

The dynamic model allows market power to change over time, so we calculate the market powers for each year. Figure 4 shows the changes of the market power and cattle supply. The cattle supply fluctuates with an increasing trend while market power fluctuates with a decreasing trend. This decreasing trend of market power is incompatible with the traditional opinion that an increase of concentration will increase market power. However, the market power for National, Nebraska, and Texas have fluctuated along with the cattle cycle over the given time period. Therefore, we can conclude that the cattle cycle causes the oligopsony market power in the cattle procurement market and that the market power has been fluctuating and declining over time. This finding also coincides with the previous studies (Stiegert, Azzam, and Brorsen 1993; Crespi, Xia, and Jones 2010).

In summary, the first null hypothesis that oligopsony market powers in the U.S. cattle procurement market equal zero is rejected in all regions and both static and dynamic model. Therefore, we can conclude that packers exert an oligopsony market power over the U.S. cattle procurement market. The second null hypotheses that the concentration, the cattle cycle, and the seasonality have no effect on the oligopsony market power are all rejected. That means the packers use the cattle supply and the seasonality to increase their margins by pricing cattle under the marginal cost of cattle production. However, the concentration has a negative effect on the oligopsony market power. That is, the markdown decreases by increasing the concentration for the sample period. This result may support the hypothesis that cost efficiency dominates the effect of market power by increasing the concentration.

Conclusions

There are many controversial issues about market power in the U.S. cattle procurement market. Many believe that the major beef processing companies attempt to merge and acquire the other companies as a viable strategy to increase their market powers. However, some studies indicate that such consolidation amongst packers leads to the increase of their efficiency in beef processing cost, rather than increasing the market power. Therefore, this study looks into the beef packing industry from the perspective that the market power may not be from the concentration, but from the characteristics of cattle production such as cattle cycle and seasonality. If the market power is caused by cattle supply, then the packers may compete with price instead of quantity. That is, following the SCP theory, when the cattle supply is short the packers might bid aggressively for procuring the cattle (low markdown) and when the cattle supply is enough the packers will bid less aggressively (high markdown).

From this view point, we use the Bertrand model that assumes price competition in the market and we compare it to the Cournot model. In addition, the dynamic model with the time varying model is used to look into the dynamic change of market conducts which is caused by the concentration, the cattle cycle, and the seasonality for the U.S. cattle procurement market. Three regions: National, Nebraska, and Texas, are estimated with the monthly data from 1980 to 2007.

The empirical results show that there exists oligopsony market power in the U.S. cattle procurement market. The oligopsony market power is influenced by the cattle cycle and seasonality. That is, the packers may tacitly collude during the excessive cattle supply period, while biding to price more aggressively during the short cattle supply period. The variation of market power equivalently changes with the cattle cycle. However, concentration has a negative effect on market power in cattle procurement market. These results suggest that it is more important to make cattle supply stable and to continue monitoring the cattle procurement market to assure a competitive performance. Nevertheless, this research is limited in estimating the Bertrand model derived from this study because the parameters to be estimated require firm level data. Therefore, additional research needs to develop a more suitable model to continue this study.

Reference

Anderson, S.P., A.D. Palma, and B. Kreider. 2001. “Tax incidence in Differentiated Product Oligopoly.” *Journal of Public Economics* 81:173-192.

Anderson, D.P., J.G. Robb, and J. Mintert. August 1996. “The Cattle Cycle.” *Managing for Today’s Cattle Market and Beyond*. U.S. Department of Agriculture and Cooperating States Extension Services.

Appelbaum, E. 1982. “The Estimation of the Degree of Oligopoly Power.” *Journal of Econometrics* 19:287-299.

Azzam, A.M. 1997. “Measuring Market Power and Cost-Efficiency Effects of Industrial Concentration.” *The Journal of Industrial Economics* 45(4):377-386.

____. and E. Pagoulatos. 1990. “Testing Oligopolistic and Oligopsonistic Behavior: An Application to the U.S. Meat-Packing Industry.” *Journal of Agricultural Economics* 41:362-370.

____. and J.R. Schroeter. 1995. “The Tradeoff between Oligopsony Power and Cost Efficiency in Horizontal Consolidation: An Example from Beef Packing.” *American Journal of Agricultural Economics* 77-4:825-836.

Breusch, T.S. 1978. “Testing for Autocorrelation in Dynamic Linear Model.” *Australian Economic Paper* 17:334-335.

Bertrand, J. 1883. “Book review of theorie mathematique de la richesse sociale and of recherches sur les principles mathematiques de la theorie des richesses.” *Journal de Savants* 67: 499–508.

Cai, X., K.W. Stiegert, and S.R. Koonts. 2009. “Oligopsony Power: Evidence from the U.S. Beef Packing Industry.” Paper presented at the Agricultural and Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting in Milwaukee, Wisconsin, July 26-29.

Crespi, J.M. and T. Xia, and R. Jones. 2010. “Market Power and the Cattle Cycle.” *American Journal of Agricultural Economics*. In press.

Diewert, W.E. 1974. “Applications of Duality Theory.” In M.D. Intriligator and D.A. Kendrick (eds.). *Frontiers of Quantitative Economics* Volume II (Amsterdam: North-Holland Publishing Company.

Godfrey, L.G. 1978. "Testing Against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables." *Econometrica* 46:1293-1302.

Koontz, S.R. and P. Garcia. 1997. "Meat-Packer Conduct in Fed Cattle Pricing: Multiple-Market Oligopsony Power." *Journal of Agricultural and Resource Economics* 21(1):87-103.

____, P. Garcia, and M.A. Hudson. 1993. "Meatpacker Conduct in Fed Cattle Pricing: An Investigation of Oligopsony Power." *American Journal of Agricultural Economics* 75:537-548.

Lepore, J.J. 2008. "Cournot Outcomes under Bertrand-Edgeworth Copmetition with Demand Uncertainty." Technical report, California Polytechnic State University, Orfalea College of Business, CA, USA, http://buiznt.cob.calpoly.edu/cob/econ/jlepore/research.html, 2008.

Lopez, R.A., A.M. Azzam, and C.L. Espana. 2002. "Market Power and/or Efficiency: A Structural Approach." *Review of Industrial Organization* 20:115-126.

Schroeter, J.R. 1988. "Estimating the Degree of Market Power in the Beef Packing Industry." *The Review of Economics and Statistics* 70(1):158-162.

Sexton, R.J. 2000. "Industrialization and Consolidation in the US Food Sector: Implications for Competition and Welfare." *American Journal of Agricultural Economics* 82:1087-1104.

Stiegert, K.W., A. Azzam, and B.W. Brorsen. 1993. "Markdown Pricing and Cattle Supply in the Beef Packing Industry." *American Journal of Agricultural Economics* 75:549-558.

Tostao, E. and C. Chung. 2005. "Horizontal Consolidation in the U.S. Food Processing Industry: Boon or Bane?" Paper presented at the Southern Agricultural Economics Association Annual Meeting in Little Rock, Arkansas, February 5-9.

U.S. Department of Agriculture. Economic Research Service. Meat Price Spreads. Available at http://www.ers.usda.gov/Data/MeatPriceSpreads/

U.S. Department of Agriculture. Grain Inspection, Packers and Stockyards Administration. *Packers and Stockyards Statistical Reports.* Available at http://www.gipsa.usda.gov/GIPSA/webapp?area=newsroom&subject=landing&topic=pub-stat

U.S. Department of Labor. Bureau of Labor Statistics. Available at http://www.bls.gov/

Zheng, X. and T. Vukina. 2009. "Do Alternative Marketing Arrangements Increase Pork Packers' Market Power?" *American journal of Agricultural Economics* 91(1):250-263.

Table 1. Descriptive Statistics of Variables Used in the Empirical Estimation (1980.1-2009.12, N=360)

Variable	Symbol	Mean	S. D.	Minimum	Maximum
National margin (cattle price based) ($/cwt)	$P-W$	10.82	2.87	4.64	21.04
Nebraska margin (cattle price based) ($/cwt)	$P-W$	11.12	2.83	4.81	22.05
Texas margin (cattle price based) ($/cwt)	$P-W$	10.39	3.09	4.63	20.38
Wholesale price of boxed beef ($/cwt)	P	201.10	29.65	146.00	292.99
National cattle price (5 market steer price) ($/cwt)	W	72.47	10.30	52.33	100.67
Nebraska cattle price (steer and heifer weighted price) ($/cwt)	W	72.16	10.27	52.70	102.63
Texas cattle price (steer and heifer weighted price) ($/cwt)	W	72.88	10.23	53.80	99.81
Herfindahl Hirschman index for steer and heifer slaughter	H	0.1606	0.0464	0.0561	0.2096
National steer and heifer slaughter weight (bil./lbs)	Q	2.6673	0.2852	2.0420	3.3290
Nebraska steer and heifer slaughter weight (bil./lbs)	Q	1.3669	0.2081	0.9169	1.8218
National steer and heifer slaughter weight (bil./lbs)	Q	0.4958	0.0625	0.3683	0.6640
Labor productivity (2000=100)	Q/X_l	97.04	8.13	83.57	112.85
Price of labor (2000=100)	v_l	88.88	27.14	44.26	138.92
Capital productivity (2000=100)	Q/X_c	102.25	1.73	99.58	105.62
Price of capital (2000=100)	v_c	78.37	20.53	45.92	111.85
Material productivity (2000=100)	Q/X_m	90.56	7.87	78.18	102.57
Price of material (2000=100)	v_m	100.83	21.26	70.50	159.97
PPI for farm products slaughter steers and heifers (2000=100)	PPI	104.63	14.32	73.28	157.47
Cycle (bil./lbs)	C	0.0036	1.4399	-2.4688	2.1768

Table 2. Estimates of the Parameters for the Bertrand and Cournot Models for the National, Nebraska, and Texas regions cattle procurement market by GMM

Parameter	Natioanl	Nebraska	Texas
M	0.0366 (0.0035)	0.0199 (0.0030)	0.0138 (0.0030)
α_{ll}	2.5482 (0.0646)	2.8537 (0.0030)	2.3866 (0.0563)
α_{cc}	0.8399 (0.0196)	0.5890 (0.0122)	0.4369 (0.0083)
α_{mm}	3.2068 (0.0881)	3.1615 (0.0783)	2.7948 (0.0716)
α_{lc}	0.1974 (0.0090)	0.1036 (0.0096)	0.2540 (0.0093)
α_{cm}	-0.8431 (0.0247)	-0.5181 (0.0154)	-0.5190 (0.0144)
α_{ml}	-2.5985 (0.0681)	-2.8287 (0.0673)	-2.4834 (0.0610)
β_l	0.2767 (0.0113)	0.1997 (0.0071)	0.0420 (0.0023)
β_c	-0.1801 (0.0094)	-0.1188 (0.0045)	-0.0477 (0.0014)
β_m	-0.1562 (0.1031)	-0.1279 (0.0069)	-0.0174 (0.0023)

Notes: All parameters are significant at the 5% significance level.
Parentheses are approximate standard errors.

Table 3. Estimates of the Parameters for the Dynamic Model for the National, Nebraska, and Texas regions cattle procurement market by GMM

Parameter	National	Nebraska	Texas
γ_0	0.0996 (0.0048)**	0.0556 (0.0068)**	0.0467 (0.0057)**
γ_1	-0.2491 (0.0193)**	-0.1017 (0.0266)**	-0.0923 (0.0231)**
γ_2	0.0082 (0.0005)**	0.0078 (0.0005)**	0.0078 (0.0005)**
γ_3	-0.0122 (0.0021)**	-0.0156 (0.0023)**	-0.0096 (0.0023)*
γ_4	0.0169 (0.0024)**	0.0138 (0.0026)**	0.0216 (0.0024)**
γ_5	0.0085 (0.0026)**	0.0049 (0.0027)*	0.0113 (0.0026)**
α_{ll}	2.2445 (0.0899)**	3.4504 (0.1371)**	2.8893 (0.1079)**
α_{cc}	1.2642 (0.0520)**	1.2656 (0.0505)**	1.1123 (0.0396)**
α_{mm}	1.5938 (0.0736)**	2.1705 (0.0993)**	1.7552 (0.0786)**
α_{lc}	-0.7592 (0.0311)**	-1.1053 (0.0434)**	-0.9295 (0.0331)**
α_{cm}	-0.3474 (0.0182)**	-0.0063 (0.0116)	-0.0282 (0.0069)**
α_{ml}	-1.4017 (0.0595)**	-2.2825 (0.0971)**	-0.8708 (0.0765)**
β_l	0.0302 (0.0191)	0.1341 (0.0158)**	0.0174 (0.0044)**
β_c	-0.1331 (0.0146)**	-0.1042 (0.0083)**	-0.0415 (0.0026)**
β_m	0.0410 (0.0147)**	-0.0690 (0.0116)**	0.0052 (0.0036)

Notes: * significant at the 10% significance level.
** significant at the 5% significance level.
Parentheses are approximate standard errors.

Table 4. Oligopsony Market Power, Markdown, and Marginal Cost for the U.S. Cattle Procurement Market

Market Power	Static Model			Dynamic Model		
	National	Nebraska	Texas	National	Nebraska	Texas
Market Power	0.0366	0.0199	0.0138	0.0629	0.0401	0.0377
(%)	(0.0035)	(0.0030)	(0.0030)	(0.0030)	(0.0036)	(0.0035)
Markdown	2.6537	1.4368	1.0039	4.5645	2.8905	2.7486
($/cwt)	(0.2525)	(0.2188)	(0.2159)	(0.2200)	(0.2578)	(0.2575)
Marginal Cost	6.7237	8.1916	8.0956	5.3866	6.9359	6.5899
($/cwt)	(0.1965)	(0.1700)	(0.1682)	(0.1763)	(0.1954)	(0.2091)

Notes: Parentheses are approximate standard errors.
All estimates are statistical significant at the 5% significance level.

Figure 1. The Concentration (HHI for Steer and Heifer) Change for U.S. Cattle Procurement Market from 1980 to 2009

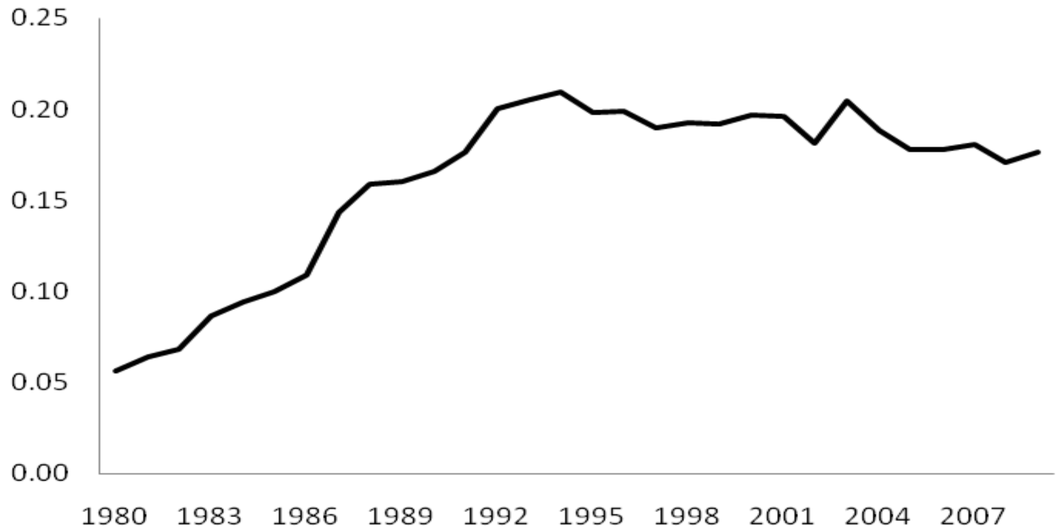

Figure 2. The Cattle Supply for the U.S. Cattle Procurement Market from 1980 to 2009

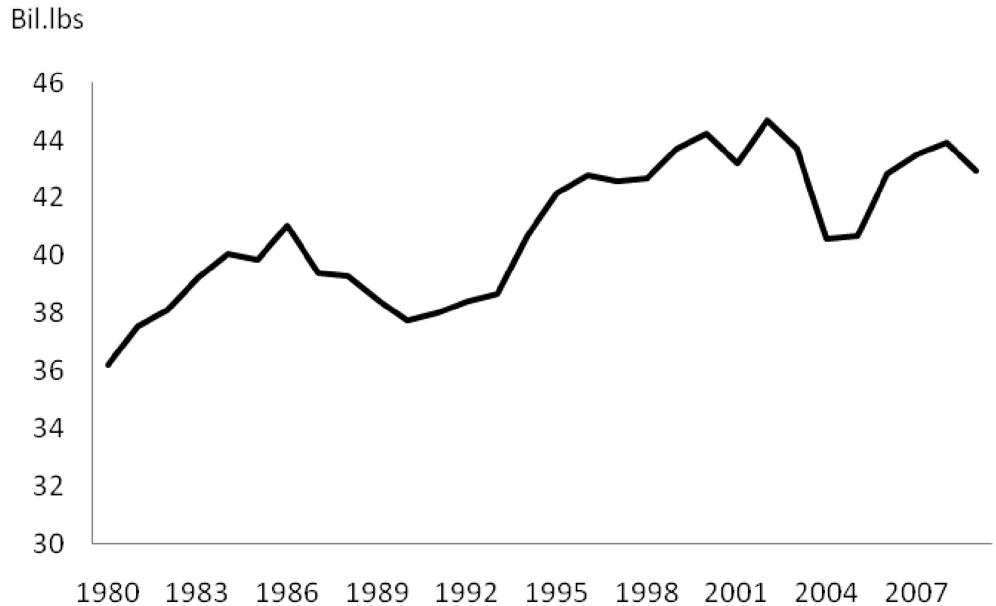

Figure 3. The Average Monthly Changes of Slaughtered Cattle for the U.S. Cattle Procurement Market from 1980 to 2009

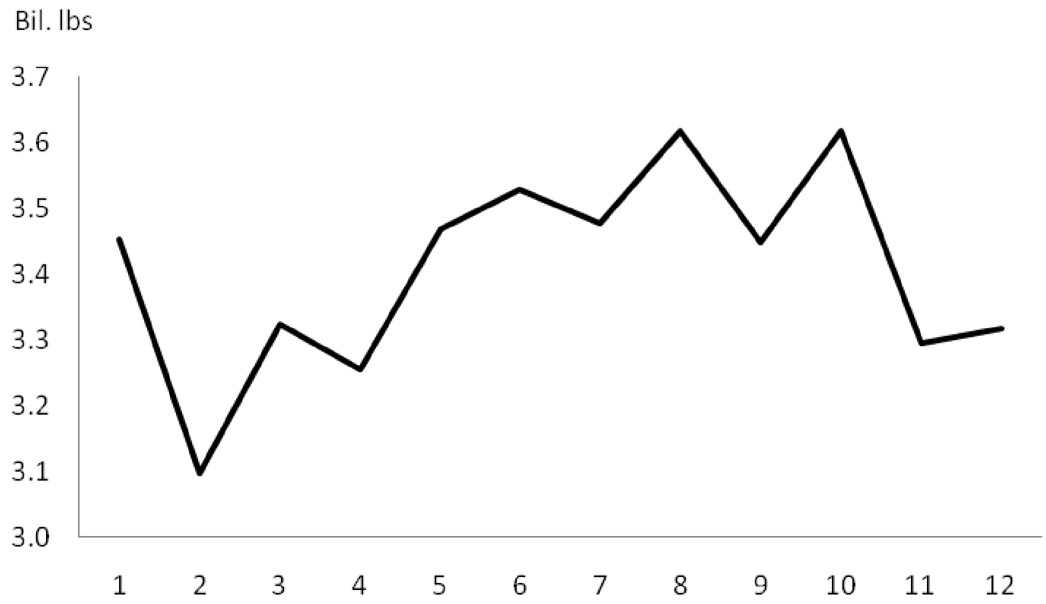

Figure 4. The Changes of Market Power and Cattle Supply for the U.S. Cattle Procurement Market from 1980 to 2007