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The Livestock Mandatory Price Reporting Act became law in April 2001 with the intent to provide more transparent market information to cattle producers. A criticism of mandatory price reporting (MPR) is that the increased price transparency may actually increase oligopsony power exercised by beef packers. We examine beefpacking margins using time periods before and after MPR was implemented with a Markov model that tests for switching between cooperative and noncooperative pricing. Switching is indicative of noncompetitive conduct and we examine the duration and magnitude of market power. One key finding is that market power is two times higher after MPR than before. The second is that, while this study produces some of the largest measures of market power associated with fed cattle pricing, market power remains rather small and is consistent with prior research. Last, we offer the caveat that there is more occurring in fed cattle and beef markets during last 20 year than the transition from voluntary to mandatory price reporting. So MPR is likely not the only cause of increased market power. But there is clearly more market power exercised in fed cattle markets after 2001 than before.

Keywords: Fed Cattle Prices, Oligopsony, Mandatory Price Reporting, Markov Switching

Introduction

The concentrated structure of the U.S. beef packing industry has been a major public policy issue for decades. As documented in Johnson and Becker (2009), the national four-firm concentration ratio (CR4) for beef packing increased from 25% in 1977 to 71% in 1992. However, since 1992, the CR4 has remained in a range between 70% and 72%. Thus, it appears that most of the industrial structural change (i.e., mergers, increased plant sizes, and decreased numbers of facilities) that led to significant increases in concentration were in place by the early 1990s.

The U.S. Congress in 1999 passed the Livestock Mandatory Price Reporting Act largely because of the perceived need for cattle producers to have access more transparent market price information and an underlying concern about the impact of the exercise of market power on fed cattle prices. Mandatory Price Reporting (MPR) was implemented in April 2001. MPR requires beef processing plants with an annual slaughter over 125,000 head to report fed cattle purchase prices and transaction quantities twice daily to the USDA Agricultural Marketing Service (AMS). This process was automated and made electronic. Prior to MPR, price reporting was voluntary in that USDA AMS market reporters contacted both sellers and buyers for prices and reported information that was confirmed. The Act was under a sunset clause and expired on September 2005. It was not renewed until October 2006 and then only for another five years (Becker 2006).[1] Price reporting occurred in the interim under the mandatory system but participation was voluntary by the packing industry.

The major intent of MPR was to improve the efficiency of pricing fed cattle through increased information. However, as Wachenheim and Devuyst (2001) discussed, it is also possible that greater price transparency may facilitate coordination among beef packers. Azzam (2003),

[1] The legislation was renewed again in late 2010.

Njoroge (2003) and Njoroge, et al. (2007) raise concerns about increased transparency, the possibility for increased coordination, and research this issue from a theoretical perspective.

While many industrial organization and market power studies have been conducted on the U.S. beef packing industry, only a handful have examined for market power exercised specifically in short-term pricing strategies. Consistently, research of this nature shows evidence of significant market power and behavior consistent with changing intensity of competition (see Koontz, Garcia and Hudson 1993, Stiegert, Azzam and Brorsen 1993, Azzam and Park 1993, Koontz and Garcia 1997, Carlberg, Hogan and Ward 2009, and Cai, Stiegert and Koontz 2011).

Cai, Stiegert and Koontz (2011), which we denote CSK, update the work of Koontz, Garcia and Hudson (1993) and used a regime switching framework with weekly beef packing margins from 1992-1999. The work which we report here replicates CSK with a slightly modified model and then examines switching conduct in the years with MPR: 2001-2010. This allows for a comparison of oligopsony pricing behavior in the fed cattle market with prior research, and specifically before and then after MPR. We are able to examine the concerns of Wachenheim and Devuyst (2001) and contribute applied research results to the conceptual and theoretical discussions so far. We also offer the work which we report as an updating of the literature. Measures of market power have been found to change over time (see Ward 2002) and thus replication is needed. Further, there have been advances in economic and econometric modeling which allow needed-assumption of prior research to be relaxed. We are able to add to the policy discussion through all these contributions.

We report several key findings. Meatpacker margins appear to fit the switching regime model quite well. This implies that pricing within fed cattle markets has periods of intense competition and periods where competition is softer. This switching behavior is inconsistent with a perfectly competitive market. So fed cattle market are less than perfectly competitive. Further, there has been a change in the last 20 years. From 2001-2010, the average cooperative phase lasted 20 weeks and the average noncooperative phase lasted 15 weeks. From 1992-1999, the average cooperative phase lasted 19 weeks and the average noncooperative phase lasted 37 weeks. The noncooperative regime is considerably shorter in duration during MPR. Further, there are separate measures of market power within each regime. While the measure in the noncooperative phase is insignificantly different from zero and this is less market power than prior to MPR, the measure in the cooperative phase is higher than during MPR. Because of these two results, duration and extent, market power was found to be more potent within the past 10 years and during MPR.

Economic and Econometric Models

Price setting games are interesting. These games can result in very competitive outcomes and can result in very collusive outcomes (see Tirole 1989). The determinate of the extent of collusion appears to be if the interactions are repeated. Do the buyers and sellers interact once or repeatedly? Repeated interactions are what occur in fed cattle markets, and in many agricultural markets, and are the most collusive. However, the most collusive outcomes require the side that is exercising the market power to know what the other firms like itself are doing. For example, the meatpacker needs to know what other meatpackers are offering and paying. This may be a

limitation. Participants in the market can still collude without perfect knowledge if there is indicator of what other like-firms are doing. For example, other like-firms behavior is revealed in reported market prices. But the collusion is less effective and results in periodic price wars.

Market participants are willing to conduct a price war if the long term gains outweigh the short term costs. This idea has been around a long time but also remains contentious (see Lott 1999). Price wars can be used to deter entry, which is a long run decision, but here are used to enforce less than competitive behavior in pricing, which is a short run decision. These are the classic economic models of Porter (1983a), Green and Porter (1984), and Abreu, Pierce and Stacchetti (1986). These works are synthesized in Mailath and Samuelson (2006). Price wars are also very much part of business school approaches to strategy. For example, in the classic work of Michael Porter (1980), pricing of homogeneous commodity products center on pricing at target rates of return, monitoring market share, monitoring rival behavior, and the recommendation was to match behavior if competitors priced aggressively.

Intuitively, the behavior within the model manifests itself in the real world cattle markets through phases of intense competition and phases where competition is softer. One important realization is that this change in intensity of competition does not persistent in perfectly competitive markets. And the existence of the resulting switching behavior is evidence of noncompetitive behavior. However, existence of this switching behavior is also not necessarily evidence of the need for antitrust action. The behavior may be an artifact of the small number of buyers and is something which is tacit. And the market power measures need to be considered with efficiencies present in large and limited numbers of firms.

This tension between economic models as to which is the correct model is impetus for two things. First, the need for further refinement of the model to find the detail that determines results and improving realism. And second, use of econometrics with encompassing empirical models that will test which economic model results most closely matches real world data. The econometric modeling in this paper is unique and innovative. The economic models make use of stochastic processes that are difficult to implement. For example, Porter (1983a) use of a T-period Markov process and Abreu, Pierce and Stachetti (1986) use a Markov process. But Porter (1983b), Koontz, Garcia and Hudson (1993) and Azzam and Park (1993) use a Bernoulli process in the empirical modeling. T-period Markov models are intractable and Markov models are likewise difficult to incorporate into structural econometric models. That was until Hamilton (1989). Hamilton developed, and Kim and Nelson (1999) expanded, approximations for these complex Markov processes that are easy to empirically implement. Thus, the switching behavior associated with noncompetitive conduct can be examined for using an empirical model that is the closest match to date for the underlying economic model.

The economic model is summarized in Mailath and Samuelson (2006)'s model of optimal collusive behavior with imperfect monitoring. Firms switch back and forth between cooperative and noncooperative regimes. Specifically, while in the cooperative regime, any observed price in the cooperative price set causes firms to continue to cooperate and any observed price in the noncooperative set causes the firms to switch to noncooperative actions. While in the noncooperative regime, any observed price in the noncooperative set causes the firms to sustain

the noncooperative action and any price in the cooperative price set prompts the transition to the cooperative action.

The theoretical model assumes that beef packers with complete but imperfect information bid for fed cattle in a repeated game. Packers purchase fed cattle and cannot perfectly observe pricing actions by other packers. Packers also have expectations about supply but cannot observe unanticipated supply shocks. Packers are assumed to maximize their expected profit. Each packer's production is determined by their own price offer for fed cattle, other packers' price offers, some exogenous variables, and unanticipated cattle supply shocks. Each packer's production increases with the own price offer, decreases with competitor prices, and increases in the supply shock.

With reasonably well-behaved underlying technology and supply and demand functions, there is a bang-bang equilibria solution to the multiple player dynamic game. In an optimal equilibrium, packers offer a price p^c in cooperative regime and they offer a price p^{nc} in a noncooperative regime. Packers choose a pricing action based on their own margins: m^c and m^{nc}. And pricing strategy is described by the following equation:

$$p_t = \begin{cases} p^c & if\ m_{t-1} \in m^c \\ p^{nc} & if\ m_{t-1} \in m^{nc} \end{cases} \tag{1}$$

In both regimes, a price strategy sufficient to trigger a switch from previous period's equilibrium is not easy due to incentive constraints. It is intuitive that while in the noncooperative regime, high prices can be effective to discourage defections from noncooperative pricing. However, if a packer is successful in obtaining a sufficiently low cattle price when the market is in the noncooperative regime, they can incite a switch to the cooperative regime.

Following CSK, beef packing margins follow a regime-switching behavior modeled using a Multivariate Markov-Switching framework given by:

$$\begin{aligned} m_t = r_t + b_t - p_t k = \nu_{st} + \beta_s \hat{y}_t + \gamma_1 w_{1t} + \gamma_2 w_{2t} + \gamma_3 (2\sqrt{w_{1t} w_{2t}}) \\ + \ \gamma_4 (2 y_t w_{1t}) + \gamma_5 (2 y_t w_{2t}) + \varepsilon_t \end{aligned} \tag{2}$$

$$\nu_{st} = \kappa_1 \eta_{1t} + \kappa_2 \eta_{2t} \tag{3}$$

$$\varepsilon_t \mid S_t : N(0, \sigma_{st}^2) \ where\ \sigma_{st}^2 = \rho_1 \eta_{1t} + \rho_2 \eta_{2t} \tag{4}$$

where m_t is the weekly margin, which is the per unit sum of two revenue streams: the boxed beef price (r_t) and the by-product price (b_t), minus the fed cattle price (p_t) converted to a carcass equivalent (k = 1/0.625), w_{1t} is a labor price, w_{2t} is an energy price, $\hat{y}_t$ is an anticipated weekly slaughter, and y_t is the actual weekly slaughter of fed cattle. Equation (3) shows that the intercept in the margin model varies across the two regimes. Within equation (4), S_t = {1,2}

indicates the two distinct regimes: $S_t = 1$ represents the noncooperative regime and $S_t = 2$ represents the cooperative regime.[2] There are also two separate variances for the two regimes.

In equation (2), besides the constant term, $\hat{y}_t$ is the only exogenous variable that is associated with switching regimes. The other terms represent marginal processing costs determined after the labor and energy prices and actual cattle supply are observed. β_s varies in the two regimes. β_1 is the parameter in the noncooperative regime, β_2 is the parameter in the cooperative regime, and $\beta_1 < \beta_2$. This term would be zero under perfect competition and is the wedge between price, or margin here, and marginal processing costs. Therefore, $(\beta_1, \beta_2, \kappa_1, \kappa_2, \rho_1, \rho_2)$ is the vector of regime-dependent coefficients, and $\gamma = (\gamma_1, \ldots, \gamma_5)$ is the vector of regime-independent coefficients. We then estimate the equations (2)-(4) using the algorithm developed by Bellone (2004 and 2005).

The expected slaughter volume of fed cattle, $\hat{y}_t$, is modeled as follows:[3]

$$y_t = \alpha + \alpha_1 y_{t-1} + \alpha_2 \text{cof}_1 + \alpha_3 p_c + \alpha_4 p_a + \sum_{i=5}^{7} \alpha_i \text{plc}_{i-1} + \sum_{i=8}^{18} \alpha_i D_i \qquad (5)$$

$$+ \alpha_{19} \text{dbseus}_i + \sum_{i=20}^{25} \alpha_i \text{cmon} + e_t$$

where y_{t-1} is slaughter in the previous week, cof_1 is the previous month's cattle on feed, p_c is the price of corn, p_a is the price of alfalfa, plc_{i-1} are cattle placements lagged 4, 5, and 6 months, and D_i are 11 monthly dummy variables. cof_1 and plc_{i-1} are used to estimate the cattle inventory, and D_i is used to capture the effect of seasonal changes. The nonstandard notation will become clear when the data are discussed.

There were two BSE (Bovine Spongiform Encephalopathy) incidents that occurred during the post-MPR years. In May of 2003, BSE was discovered in Canada and the trade of fed cattle to the U.S. halted. And in December of 2003, BSE was discovered in the U.S. Because there was much uncertainty in the market for cattle and beef, we created the dummy variables to control the effect the two BSE incidents on U.S. weekly cattle slaughter. These variables are not present in the 1992-1999 model and are included in the 2001-2010 model. Specifically, the variable dbseus is one for weeks between December 24, 2003 and April 10, 2004 and zero elsewhere. And exports of Canadian fed cattle were prohibited between May 20, 2003 and July 18, 2005. This dummy variable is interacted with monthly dummies during the first and fourth quarters of

[2] The regime switching process is stationary and defined by two probabilities: the probability of staying in the cooperative regime and the probability of staying in the noncooperative regime. The probabilities of the market switching regimes are then also defined. Specifically, $\text{Prob}[S_t = 1 \mid S_{t-1} = 1] = p$, $\text{Prob}[S_t = 2 \mid S_{t-1} = 1] = (1 - p)$, $\text{Prob}[S_t = 2 \mid S_{t-1} = 2] = q$, and $\text{Prob}[S_t = 1 \mid S_{t-1} = 2] = (1 - q)$.

[3] The slaughter volume model specification is based on the model developed in Stiegert, Azzam and Brorsen. (1993).

the year because these are the quarters when Canadian fed cattle slaughter is the largest. This model is very similar to CSK. The difference is the inclusion of alfalfa price and the BSE disruption dummy variables. An autoregressive process is also included on the error term.

Data and Estimation Results

The data sets were collected from three sources: Livestock Marketing Information Center (LMIC), National Agricultural Statistics Service (NASS) and the Department of Labor. The fed cattle price is the weighted average price from the five major regional markets. The boxed beef price is the composite price constructed from different primal cut prices. The byproduct value is also a composite of major byproduct prices. All are weekly series. The slaughter volume is from the weekly Livestock Slaughter report. Cattle on feed and cattle placements are from the monthly Cattle on Feed report. Corn and alfalfa price data are from the monthly Agricultural Prices report. The energy price index is from the producer price index for fuels and power and the labor price is the average weekly production worker earnings for the meat packing industry. All the price are deflated to a 1992 base year for the models using 1992-1999 data and to a 2001 base year for models using the 2001-2010 data. Table 1 reports summary statistics for the data.

The interval of observation is weekly. The fed cattle market is effectively a weekly market. Bid and ask are conducted through the week and there is a window during the week where almost all transactions take place. This is a difference with Koontz, Garcia and Hudson (1993) that used daily price data, Stiegert, Azzam and Brorsen (1993) that used quarterly data, and Carlberg, Hogan and Ward (2009) that used transactions data albeit from a simulated market. It is our interpretation that weekly data are the most appropriate interval for examining pricing strategy and market power. For the variables that are not available weekly, the monthly observation is used for all weeks in that month. This results in the nonstandard model notation in equation (5). No interpolation was conducted.

The results for the two fed cattle slaughter volume models are reported in Table 2. The coefficient on slaughter volume lagged one week was highly significant and it is the most important variable in the model. Slaughter is a flow from a production stock. The production stock adjusts slowly and prior flows explain current flows. The cattle on feed inventory variable lagged one month is statistically significant in the pre-MPR period and insignificant in the post-MPR period. This is opposite from placements variables. Placements into feedlots 4-6 months prior were insignificant in the pre-MPR period and significant in the post-MPR period. The seasonal dummy variables are next in terms of importance in explaining slaughter volumes. The weights of feeder cattle placed into feedlots and consequently inventories of cattle on feed vary seasonally and this is not observed by variables counting numbers of head. The seasonal dummies capture the impact of seasonal variation in placement weights on slaughter. The corn price and alfalfa price were both insignificant in both models. These variables are included to demonstrate no input costs impact slaughter once animals are placed on feed. The U.S. BSE disruption dummy variable was statistically significant, as were some of the dummies which were interactions between BSE in Canada and seasonal dummies. During the BSE market disruptions, fed cattle slaughter was reduced and was reduced seasonally when the Canadian fed cattle not available.

The model goodness of fit suggests that the variables used can provide a reasonable measure of anticipated supply. We use these models predictions in-sample within the margin model. Doing so assumes the packing industry knows the underlying data and conditions in fed cattle supply. It is a proxy for industry expectations of fed cattle volume slaughter. It also is the variable that determines one market power measure. Margins are largely driven by costs and specifically marginal costs. However, the anticipated slaughter is used to measure the wedge between packer margins and these marginal costs. And it is the difference between actual slaughter and anticipated slaughter that captures the tension in the market and the ability of the packer to deviate from marginal cost pricing – and thus exercise market power.

Figures 1 and 2 present the beef packer margins graphically for the two time periods. Margins are relatively small in the 1992-1999 time period and larger for 2001-2010. There is a gradual increase in the first period and a gradual softening in the second. Volatility is also clearly larger in the second period. The margin model estimates are reported in Table 3. The upper portion of the table reports regime-independent parameters. Three of the five γ terms are statistically significant, which indicates that the marginal processing cost components have an impact on the margin variations. While the individual marginal cost parameters appear rather different, using the parameters with there variables to construct a predicted value for the marginal processing cost variable is useful. The predicted marginal processing costs average 92.9% of margins in the first sample, 91.5% of margins in the second sample, and vary extensively with the margin.

The lower portion of Table 3 contains the regime-dependent parameters and duration results. In the post-MPR years, all the regime-dependent estimates except β_1 are statistically significant. The conditional probability of remaining in the noncooperative regime (p) is 0.933. This parameter is used to calculate the expected duration of remaining in a noncooperative state, which is 15 weeks.[4] The conditional probability for the cooperative regime (q) is 0.951 and results in an expected duration of 20 weeks. The duration of noncooperative regime is much shorter and the duration of cooperative regime is slightly longer during 2001-2010 than 1992-1999. Prior to MPR, the conditional probability of remaining in the noncooperative regime is 0.973 and the expected duration of the noncooperative phase is 37 weeks. The conditional probability for the cooperative regime is 0.946 and results in an expected duration of 19 weeks. This suggests that the post-MPR period has noncooperative regimes that are less stable and the firms are more able to enter into the cooperative regimes. Our results also show that we would expect the firms to be in a cooperative state 58% of the weeks each year since 2001, which compares to 34% of the weeks prior to MPR.[5]

The next two regime-dependent parameters (β_1 and β_2) measure extent of market power in the noncooperative and cooperative regime. β_1 is statistically insignificantly different from zero in the 2001-2010 period so the market is not different from the perfectly competitive market during the noncooperative regime. β_2 is statistically significant, which indicates that there is market

[4] The expected duration for each regime is: $\sum_{\lambda=1}^{\infty}\lambda p^{\lambda-1}(1-p)=(1-p)^{-1}$ and $\sum_{\lambda=1}^{\infty}\lambda q^{\lambda-1}(1-q)=(1-q)^{-1}$.

[5] Calberg, Hogan and Ward (2009) use data from an experiment where the simulated market is structured with real-world parameters to study switching behavior in the beef packing industry. They found market participants remained in the cooperative regime for 40% to 80% of the time.

power exercised during the cooperative regime in the post-MPR years. Prior to MPR, both β_1 and β_2 are significant. This implies that market power is exercise in both noncooperative and cooperative phases. And, through examining the magnitudes we see the extent of market power, prior to MPR, is larger in the cooperative phase as well. However, this does not imply that more market power is exercised prior to MPR. Market power must be measured net of the share of the margin associated with marginal costs. Further, the extent of market power must be combined with the duration. All of these factors will be examined systematically below.

The regime-dependent constant coefficients, κ_1 and κ_2, are statistically significant and quite different in magnitude. These parameters describe the intercept of the margin model during the two phases. During the noncooperative phases the margin is negative and during the cooperative phases it is positive. Negative margins are not consistent with competitive or imperfectly competitive models and these terms are not factored into the market power calculations. This appears to be topic for future research. The estimates of regime-dependent variances, ρ_1 and ρ_2, are significant and show variation across regimes and across time periods. These findings suggest that each regime operates quite differently and the larger variances since 2001 helps explain why switching is more common in the post-MPR period.

Using Hamilton's (1989) filter technique for determining each regime switch, we can also present interesting findings. Figures 3 and 4 show the inferred probabilities of the fed cattle market being in each regime at each sample observation. The unshaded regions represent the weeks in the noncooperative regime and the shaded regions represent weeks in cooperative regime. There are 12 cooperative periods between April 2001 and May 2010. One of the longest cooperative period occurred in 2006 when MPR had expired and the prices reported under the mandatory system were voluntarily provided. By the end of the second sample period, there was a pattern developing of cooperative pricing along with short intermittent breakdowns. This is as opposed to six cooperative periods between July 1992 and February 1999. There is a particularly long noncooperative phase early in the sample time period and another long noncooperative phase late in the sample. The duration of cooperation is clearly shorter and less likely prior to MPR.

It is our interpretation that these duration results appear rather reasonable. When beef packing margins were the tightest, during most of the first sample time period and prior to MPR, it appears that packers are competing aggressively and it is easy to argue the industry is in a noncooperative phase. This aggressive competition is also when actual slaughter is small and the negative margins suggest it is not sustainable. When beef packing margins where the widest, in much of the second sample time period and early in this sample period – during MPR, cooperative phases and the exercise of market power are most likely. Examining the post-MPR results more closely (Figure 4), we see that specifically when margins widen, this usually occurs in April and during the summer seasons with strong demand, the packing industry is more able price in a less competitive manner. This transition to cooperation also occurs when actual slaughter is larger than expected slaughter.

Using duration and extent of market power measures, Table 4 presents a comparison of the average calculated marketing margins. As shown in the first three rows, the marketing margins

and difference between regimes are much wider in 2001-2010 than compared to 1992-1999. This is not a problem because we have not accounted for changes in marginal costs across the two study periods or across regimes within each study period. The parameter estimates for β_1 and β_2 can be used to measure the share of each regime-dependent marketing margin that is associated with market power, which implicitly accounts for marginal processing costs. During MPR, the share of the margin associated with market power during the cooperative regime is 4.04% and the share during noncooperative regime is 0%. Prior to MPR, the share of the margin associated with market power during the cooperative regime is 3.38% and the share during noncooperative regime is 2.35%. The share of margins associated with market power in the cooperative regime is higher while the share in the noncooperative regime is lower in the post-MPR sample compared to the pre-MPR sample.

The gains due to market power are $2.78 per head per year in 2001 dollars during the 2001-2010 time period. Specifically, a reasonable fed animal carcass weight was 800 pounds so during the cooperative phase (8 cwt per head)×($14.91/cwt×0.0404)×0.578 = $2.78 per head. There was no market power exercised in the noncooperative phases. In the 1992-1999 time period, we find that gains are $0.87 per head per year in 1992 dollars. Again, a reasonable fed animal carcass weight was 700 pounds. So during the cooperative phase (7 cwt per head)×($7.87/cwt×0.0338) ×0.333 = $0.62 per head, during the noncooperative phase (7 cwt per head)×($2.29/cwt×0.0235) ×0.667 = $0.25 per head, and this results in a total of $0.87 per head.

The increase in market power exercised through pricing behavior is clear. The additional annual economic profits accruing to the beef packing industry after MPR is over two times the annual average economic profit accruing prior to MPR.[6] But the argument that it is due to MPR requires some caveats. In one sense, we surprised by the result. Beef packers by the nature of their business have better information than cattle producers. There are fewer firms and communication is constant within each firm. It is relatively easy for each packer to know what other packers are bidding through each week simply by communicating with cattle feeders in the bid-ask process. It is unlikely that MPR provided packers much information that they did not already have. Nonetheless, our results are quite consistent with concerns expressed Wachenheim and Devuyst (2001). We recognize we are not directly testing the impact of MPR on market power. Our approach is like all event studies or studies based on dummy variables that have a before and after sample. There is always some uncertainty that the event is not the only cause of the change. But the results persist. Indeed the role of increased information appears to limit the duration of aggressive competition when there is a breakdown in the cooperation regimes, which is quite reasonable. And if the change in information provided by MPR is the cause of the increase in market power then, in oligopsonistic settings, information is a double-edged sword, and in this industry, it appears to favor greater levels of tacit coordination.

Conclusion

High levels of concentration and the associated oligopsony power in the U.S. beef packing has been a major public policy concern for many decades. One possible way to mitigate market power is to provide market participants with more information. In 1999, the Livestock

[6] $1 in 1992 is $1.26 in 2001, so $0.87 in 1992 dollars is $1.10 in 2001 dollars.

Mandatory Price Reporting Act was passed, which was intended to increase fed cattle price transparency and provide more information to the cattle producers. Price reporting under the Act began in April of 2001. In this article, we empirically evaluated the U.S. beef market using a regime-dependent switching regression model. The results provide evidence that the switching regression model is a good representation of the data generating process for beef packer margins. Our analysis indicates that cooperative regimes lasted 20 weeks while noncooperative regimes lasted an average of 15 weeks of noncooperation duration. Compared with data prior to MPR, we find that regime switching becomes more frequent and less stable in the post-MPR years. Our empirical results offer support for hypotheses developed in previous conceptual and mainly theoretical studies (Wachenheim and DeVuyst 2001; Azzam 2003; Njoroge 2003; and Njoroge et al. 2007) that the MPR Act could assist beef packers in increasing their market power. In particular, we show that, market power brings twice as much annual additional economic profit in the post-MPR years compared to the pre-MPR years. The results cast doubt that MPR is having its intended pro-competitive effects on the market.

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Table 1: Descriptive Statistics of Data Variables.

	Variable	Mean	Std Dev	Min	Max
2001-2010 (476 observations)	slaughter (1000 head)	524.11	46.50	352.6	656.8
	$cof._{-1}$ (1000 head)	10972.73	629.13	9590	12110
	p_{corn} ($/bu)	2.78	0.78	1.88	6.10
	p_{alpha} ($/ton)	101.51	14.88	80.85	147.01
	$plc._{-4}$ (1000 head)	1946.83	318.36	1391	2788
	$plc._{-5}$ (1000 head)	1948.33	323.12	1391	2788
	$plc._{-6}$ (1000 head)	1961.03	327.30	1391	2829
	margin ($/cwt boxed beef)	11.76	5.44	0.27	39.49
	wage ($/week)	658.55	42.15	580	739
	energy index	148.09	40.29	82.50	268.70
1992-1999 (348 observations)	slaughter (1000 head)	525.11	43.61	365.5	624.73
	$cof._{-1}$ (1000 head)	7883.37	801.97	6237	9718
	p_{corn} ($/bu)	2.30	0.47	1.56	3.91
	p_{alpha} ($/ton)	83.31	8.03	67.40	108.47
	$plc._{-4}$ (1000 head)	1611.08	355.50	1068	2536
	$plc._{-5}$ (1000 head)	1602.64	348.26	1068	2536
	$plc._{-6}$ 1000 head)	1596.31	343.17	1068	2536
	margin ($/cwt boxed beef)	4.13	3.40	-2.95	15.47
	wage ($/week)	363.49	34.30	304	416
	energy index	108.84	6.05	93.9	119.4

Table 2: Estimates of Weekly Slaughter Volume Models

	2001-2010		1992-1999	
Variable	Estimate	Std Dev	Estimate	Std Dev
cons.	120.531***	(39.589)	112.744***	(29.195)
y_{t-1}	0.462***	(0.042)	0.365***	(0.040)
$cof._{-1}$	0.002	(0.009)	0.024***	(0.005)
p_{corn}	-2.672	(2.353)	9.562***	(3.127)
$P_{alfalfa}$	0.050	(0.133)	-0.251	(0.197)
plc_{-4}	0.022**	(0.009)	0.003	(0.014)
plc_{-5}	0.026***	(0.009)	0.006	(0.014)
plc_{-6}	0.015*	(0.008)	-0.0002	(0.013)
mon2	-18.994**	(8.019)	-5.406	(9.032)
mon3	-12.428	(9.284)	-9.560	(13.132)
mon4	17.900*	(10.966)	12.331	(15.491)
mon5	51.645***	(9.433)	42.242***	(12.396)
mon6	60.228***	(10.159)	41.351***	(12.530)
mon7	37.373***	(9.729)	33.932***	(10.310)
mon8	55.085***	(10.317)	57.886***	(12.637)
mon9	27.911***	(9.560)	45.183***	(11.304)
mon10	30.362***	(9.757)	41.288**	(12.993)
mon11	13.372	(9.357)	3.169	(10.757)
mon12	-6.207	(8.018)	-27.156**	(8.498)
dbseus	-21.445***	(9.487)		
cmon1	-11.711	(11.421)		
cmon2	-10.779	(11.732)		
cmon3	5.411	(11.742)		
cmon10	-16.645*	(10.300)		
cmon11	-35.261***	(11.214)		
cmon12	-9.669	(10.494)		
Adjusted R^2	0.67		0.66	

*** $p < 0.01$, **$p < 0.05$, * $p < 0.10$.

Table 3: Maximum Likelihood Estimates of Markov Regime Switching Model.

		2001-2010		1992-1999	
	Parameters	Estimate	Std Dev	Estimate	Std Dev
Regime-Independent	γ_1	0.407***	(0.132)	-3.205***	(0.975)
	γ_2	-1.560**	(0.803)	-1.493***	(0.530)
	γ_3	-0.068	(0.239)	2.999***	(0.875)
	γ_4	-0.235	(0.212)	0.731	(0.545)
	γ_5	1.273**	(0.634)	-0.358	(0.370)
Regime-Dependent	p	0.933***	(0.020)	0.973***	(0.011)
	q	0.951***	(0.015)	0.946***	(0.022)
	β_1	-0.007	(0.067)	0.180***	(0.056)
	β_2	0.155***	(0.062)	0.223***	(0.071)
	κ_1	-0.752***	(0.053)	-0.516***	(0.035)
	κ_2	0.544***	(0.059)	0.922***	(0.075)
	ρ_1	0.288***	(0.033)	0.194***	(0.020)
	ρ_2	0.610***	(0.056)	0.496***	(0.066)
Expected Duration	Noncooperative	14.9		37.0	
	Cooperative	20.4		18.5	
Log-Likelihood		-541.88		-304.11	

*** $p < 0.01$, **$p < 0.05$, * $p < 0.10$.

Table 5: Average Margin Results for Cooperative and Noncooperative Regimes.

Variables	2001-2010	1992-1999
Cooperative Margin	$14.91/cwt	$7.87/cwt
Noncooperative Margin	$7.71/cwt	$2.29/cwt
Difference	$7.20/cwt	$5.58/cwt
Market Power (% of cooperative margin)	4.04%	3.38%
Annual average economic profit per head	$2.78/head	$0.62/head
Market Power (% of noncooperative margin)	0%	2.35%
Annual average economic profit per head	$0/head	$0.25/head
Total annual average economic profit.	$2.78/head	$0.87/head

Note: $1 in 1992 is $1.26 in 2001.

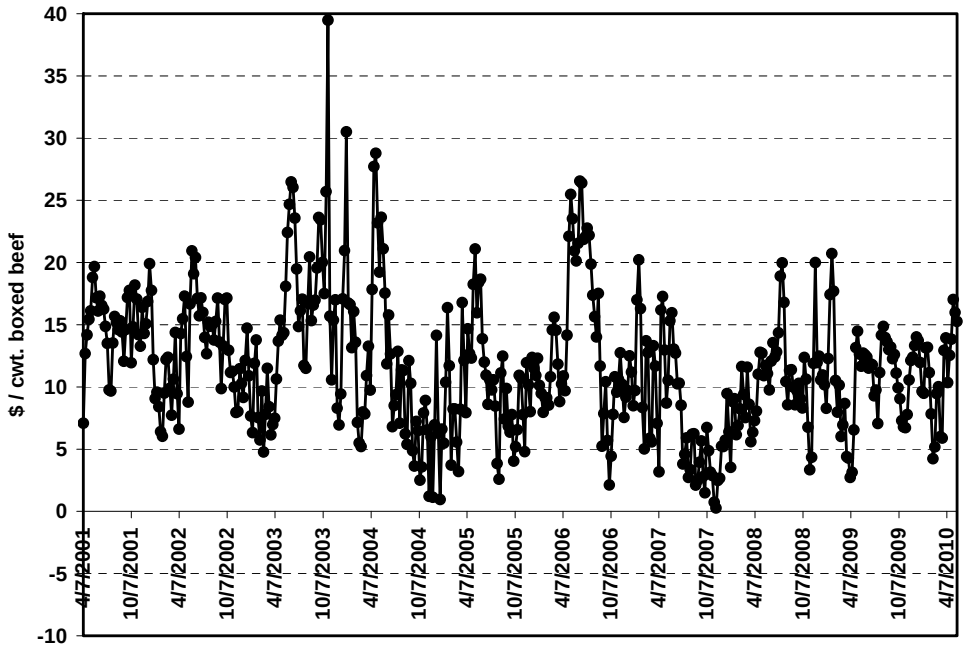

Figure 1: Beef Packer Margins for April 2001 – May 2010.

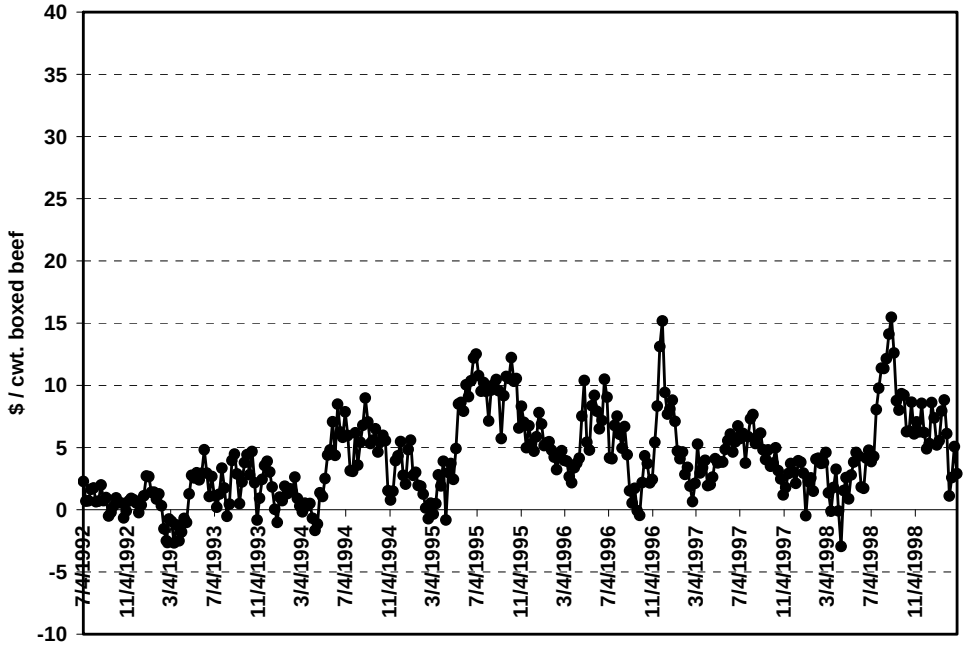

Figure 2: Beef Packer Margins for July 1992 – February 1999.

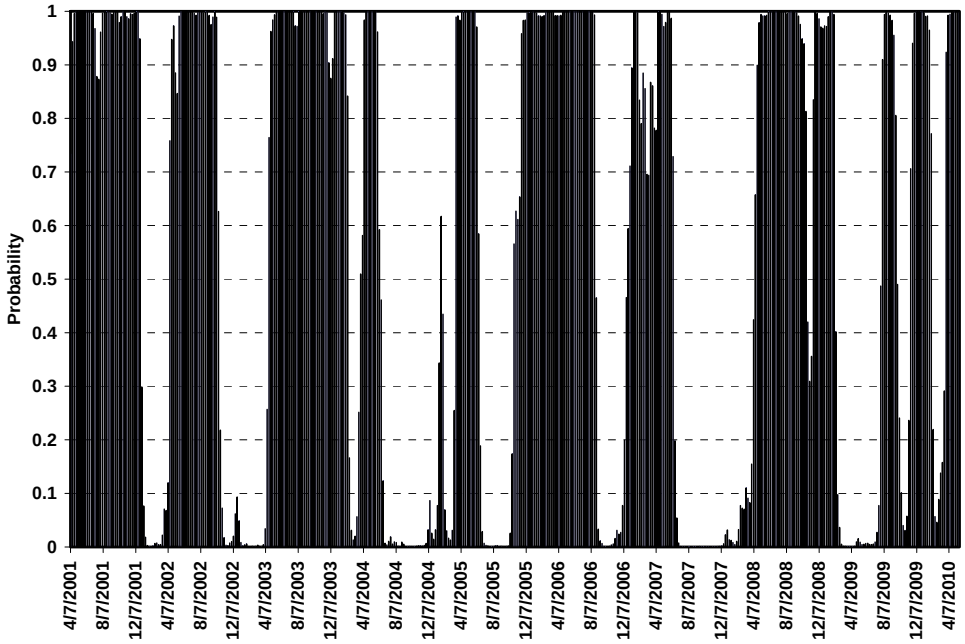

Figure 3: Probability of cooperative regime, April 2001 – May 2010. (Shaded regions identify periods of cooperative regime.)

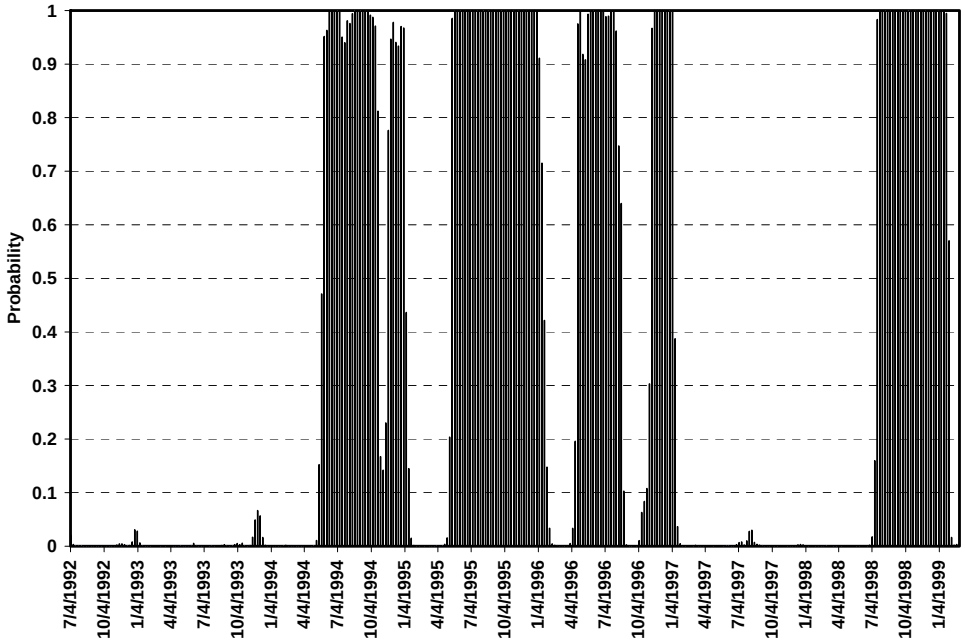

Figure 4: Probability of cooperative regime, July 1992 – February 1999. (Shaded regions identify periods of cooperative regime.)