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Oligopsony Fed Cattle Pricing: Did Mandatory Price Reporting Increase Meatpacker Market Power?

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Abstract *We study beef packing margins before and after mandatory price reporting (MPR) was implemented in 2001 using a model that identifies and tests for switching between cooperative and non-cooperative regime pricing. Our results show that after MPR took effect, the duration of non-cooperative regimes was considerably shorter, while cooperative regimes were longer. Oligopsonistic rent, as measured by average economic profit, rose from $0.88/head in the 1990s to $2.59/head after 2001. While MPR is not likely the sole cause for such an increase, there was clearly more market power being exercised in fed cattle markets in the years after the program was implemented than before.*

Key words: Cattle prices, oligopsony, mandatory price reporting, regime switching.

JEL Classification: L11, L13, D43.

Introduction

The concentrated structure of the U.S. beef packing industry has been a major public policy issue for many decades. As documented in Johnson and Becker (2009), the national four-firm concentration ratio (CR4) for beef packing rose from 25% in 1977 to 71% in 1992.[1] Since 1992, however, the CR4 has ranged between 70-72%. Thus, it appears that most of the industry's structural changes (mergers, increased plant sizes, and decreased

[1]*The national Herfindahl-Hirschmann Index (HHI) exceeded 1,800 for the first time in 1992, which is a threshold used by the U.S. Department of Justice to identify highly concentrated industries (Whinston 2008).*

number of facilities) that led to significant increases in concentration were in place by the early 1990s.

In 1999, the U.S. Congress passed the Livestock Mandatory Price Reporting Act; their motivation was largely based on the premise that cattle producers should have access to more transparent market price information, as well as an underlying concern about the impact of oligopsony power on fed cattle prices. Thus, Mandatory Price Reporting (MPR) was implemented in April 2001, which requires beef processing plants with an annual slaughter of over 125,000 head to report fed cattle purchase prices and transaction quantities twice daily to the United States Department of Agriculture's (USDA) Agricultural Marketing Service. Prior to MPR, price reporting was voluntary in that USDA market reporters contacted both sellers and buyers, usually by phone, for prices and reported confirmed information. The price reporting act expired on September 2005 and was not renewed until October 2006, and then only for another 5 years (Becker 2006)[2]. Price reporting occurred in the interim under the mandatory system, but participation by the packing industry was voluntary.

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

While many industrial organization and market power studies have been conducted on the U.S. beef packing industry, only a handful have examined market power exercised specifically in short-term pricing strategies and how those measures of oligopsony power have changed over time. Research of this nature shows evidence of significant oligopsony power and behavior consistent with the changing intensity of competition (for example, 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) updated the work of Koontz, Garcia and Hudson (1993) using a regime-switching framework with weekly beef packing margins from 1992-1999. The work reported here replicates the authors' previous work with a slightly modified model, and then examines switching conduct on a weekly basis in the years before MPR (July 1992 – February 1999) and during MPR (April, 2001 – May, 2010). This allows us to compare oligopsonistic pricing behavior in the fed cattle market with prior research, and specifically before and after MPR. Measures of oligopsony power have been found to change over time (Ward 2002) and thus replication is needed. Further, there have been advances in economic and econometric modeling which allow required assumptions of prior research to be relaxed. We are also able to add to the policy discussion through all these contributions.

Several key findings can be reported. First, beef packing margins appear to exhibit the conditions for a switching regression model quite well. What this implies is that pricing within fed cattle markets has periods of intense competition and periods where competition is softer. This

[2] *The legislation was renewed again in late 2010.*

switching behavior is simply inconsistent with a perfectly competitive market; fed cattle markets are less than perfectly competitive. Further, there has been a change in the last 20 years; while the average duration of the cooperative phase during MPR lasted about the same as pre-MPR, the non-cooperative phases became much shorter after MPR was implemented. It appears that beef packers were able to considerably shorten the duration of the non-cooperative regimes during the MPR period.

We also report what percentage of the beef packer's marketing margin is due to oligopsony power. We observe very little oligopsony power in the non-cooperative periods (0% under MPR, and 1.13% pre-MPR). In the cooperative periods, oligopsony power is higher (4.02% under MPR, and 2.91% pre-MPR) in the latter period when MPR was active. Using these findings, we show that economic profit has risen from $0.88/head in the 1990s to $2.59 per head after 2001. Oligopoly and oligopsonistic market structures create a myriad of ways for firms to extract economic rents from downstream and upstream participants. As a result, we cannot assign a specific causal relationship between the increase in oligopsony power after 2001 and the introduction of MPR. However, our results provide no evidence that MPR generated a pro-competitive environment, and they are consistent with the concerns that MPR may serve as a facilitating device for beef packers to increase their oligopsony power.

Economic and econometric models

Price-setting games of strategy can result in competitive outcomes and they can result in collusive outcomes (Tirole 1989). Determining the extent of collusion appears to be more accurate if the interactions are repeated. Do the buyers and sellers interact once or repeatedly? Repeated interactions are what occur in fed cattle markets, as well as in many agricultural markets, and have the potential to be the most collusive. However, the most collusive outcomes require the side that is exercising the oligopsony power to know what the other firms 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 an indicator of what other like-firms are doing. For example, other like-firms' behavior is revealed in reported market prices. However, 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 remains contentious (see Lott 1999). Price wars can be used to deter entry – a long run decision – but are here used to enforce less than competitive behavior in pricing – a short run decision. These are the classic economic models of Porter (1983a), Green and Porter (1984), and Abreu, Pierce and Stacchetti (1986), which 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 homogeneous commodity products centers on pricing at target rates of return, monitoring market share, monitoring rivals' behavior, and (it was recommended) matching behavior if competitors priced aggressively.

Intuitively, the behavior within the model manifests itself in real-world cattle markets through phases of intense competition and phases where competition is softer. One important realization is that this change in intensity is not persistent in perfectly competitive markets. Thus, the existence of the resulting switching behavior is evidence of non-competitive behavior. However, existence of switching behavior is not evidence per se of an antitrust violation such as collusion or price fixing. Rather, it may also be an artifact of the small number of buyers interacting in a tacit manner. This tension behind determining the correct economic model provides impetus for two things: first, further refinement of the model to discover the detail that determines results and improves its realism; second, using econometrics with encompassing empirical models to test which economic model's results most closely match real world data.

The econometric modeling followed in this paper is both unique and innovative; the models make use of stochastic processes that are difficult to implement.[3] Early theoretical developments that restricted each regime to a fixed period of time are, for all practical purposes, intractable in empirical work. Stochastic processes using a standard Markov process were difficult to incorporate into structural econometric modeling until Hamilton (1989) developed approximations for complex stochastic processes that are relatively easy to implement (Kim and Nelson (1999) later expanded on this work). Thus, the switching behavior associated with non-competitive conduct can be examined 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's (2006) model of optimal collusive behavior with imperfect monitoring: firms are allowed to periodically switch back and forth between cooperative and non-cooperative regimes based on the rules of the algorithm. The duration of each regime is not fixed. In the cooperative regime, any observed price in the cooperative price set causes firms to continue to cooperate, and any observed price in the non-cooperative set causes the firms to switch to non-cooperative actions. While in the non-cooperative regime, any observed price in the non-cooperative set causes the firms to sustain the non-cooperative action, and any price in the cooperative price set prompts transition to the cooperative action.

The theoretical model assumes that beef packers participate in a repeated game when purchasing live cattle; they bid to purchase live cattle, but have imperfect information about the bids for fed cattle from other competitors. They also have expectations about the supply of market-ready cattle. Differences between the number of cattle slaughtered and the anticipated supply provide information to each packer about the degree of competition in the market that week. Each packer gauges the degree of price competition based on their own margin. Beef packers are assumed to maximize their expected profit. Each beef 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 beef packer's production increases with their own price offer, decreases with competitor prices, and increases in the supply shock.

[3] *Abreu, Pierce and Stachetti (1986) use a Markov process. Porter (1983b), Koontz, Garcia and Hudson (1993), and Azzam and Park (1993) use a Bernoulli process.*

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 price p^c in the cooperative regime and offer price p^{nc} in a non-cooperative 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:

$$S_{it} = \begin{cases} p^c & \textit{if } m \in m^c \\ p^{nc} & \textit{if } m \in m^{nc} \end{cases}. \tag{1}$$

In both regimes, a price strategy sufficient to trigger a switch from the previous period's equilibrium is challenging due to incentive constraints. It is intuitive that while in the non-cooperative regime, high prices can be effective for discouraging defections from non-cooperative pricing. However, if a packer is successful in obtaining a sufficiently low cattle price when the market is in the non-cooperative regime, their action and subsequent price signal can duce other packers lower their price leading to a switch to the cooperative regime.

The details of our econometric model and the regime-switching algorithm are discussed in Cai, Stiegert, and Koontz (2011). What follows is a brief outline of our procedures. Beef packing margins follow a regime-switching behavioral pattern described by:

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

Equation (2) describes how the weekly marketing margin ($m_t = r_t + b_t - p_t k$) is modeled. The components of the beef packer margin include 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 ($k = 1/0.615$). The econometric model of the marketing margin is described by the second row of equation (2). Marginal processing costs play a critical role in explaining movement in the marketing margin. The five components of marginal processing costs appear in equation (2) with assigned parameters$\gamma_1 \ldots \gamma_5$. Note that the terms with an s subscript are regime-dependent and the error term $\varepsilon_t | S_t$ is conditional on the regime during the estimated week. For the time-dependent parameters, subscript $s = 1$ refers to the non-cooperative regime and subscript $s = 2$ refers to the cooperative regime. Thus, we report regime-dependent intercepts (κ_1 and κ_2) and regime-dependent variances of the regression (ρ_1 and ρ_2).

The parameter (β_s) is regime-dependent and provides an estimate of oligopsony power within each regime. The variable $\hat{y}_t$ is the anticipated supply of live cattle. Following Cai, Stiegert, and Koontz (2011), we expect that this variable has an important role in determining switching patterns in live cattle market procurement patterns. When $\hat{y}_t$ is small, we expect beef packers to be more aggressive in procuring supply, possibly leading to reductions in oligopsony power and/or breakdowns in cooperative behavior ($\beta_1, \beta_2 \geq 0$) In addition, we expect that oligopsony power will be higher in the cooperative phases ($\beta_1 < \beta_2$). If β_s is insignificant (that is, not statistically different from zero), it reflects the condition of perfect competition in the estimated regime. If β_s is positive and significant, it provides a measure of the extent of oligopsony power in the associated regime. We estimate equation (2) for two time periods: one after MPR was implemented (April, 2001-February, 2010) and one before the MPR period (July, 1992–May 1999). We purposely avoided the weeks in 1999–2001 when the MPR program was approved but not yet in operation. For the model to use the expected slaughter volume in measuring oligopsony power, we need an estimate of $\hat{y}_t$. Note that we are interested in obtaining an estimate that is not influenced by the demand-side factors. If switching is to hinge on the tension associated with how hard it is to procure market-ready cattle, we need to obtain an estimate of the supply when the market-ready supply is too plentiful or not plentiful enough. To do this, we develop a regression model (hereafter called the auxiliary slaughter model) which is used to calculate $\hat{y}_t = y_t - e_t$. This model is similar to Cai, Stiegert, and Koontz (2011) and follows a procedure developed in Stiegert, Azzam, and Brorsen (1993). The differences between our model and Cai, Stiegert, and Koontz (2011) are: a) the inclusion of alfalfa prices in the regressions for both periods; and b) the inclusion of BSE disruption dummy variables in several periods after MPR was implemented. The auxiliary regression setup and a table of results are presented in the appendix. This model utilizes information from cattle on feed reports, previous week slaughter levels, input prices, and seasonal supply. The model's goodness-of-fit suggests that the variables used can provide a reasonable measure of anticipated supply. We use the predictions from an auxiliary slaughter model to estimate the margin model in equation (2). Doing so assumes the packing industry is aware of the underlying data and conditions in the fed cattle supply; it is thus a proxy for industry expectations of the market-ready supply of fed cattle. It also is the variable that is used to estimate the degree of oligopsony power in each regime.

Data and estimation results

The examined data sets were collected from three sources: the Livestock Marketing Information Center (LMIC), the National Agricultural Statistics Service (NASS) and the United States 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 data sets are weekly series. The slaughter volume is taken from the weekly Livestock Slaughter report. The energy price index is taken from the producer price index for fuels and power, and the labor price is the average weekly production worker's earnings in the meat packing industry. All prices are deflated using the U.S. consumer price index to a 1992 base year for the models using 1992-1999 data, and to a 2001 base year for models using 2001-2010 data. Table 1 reports summary statistics for the data.

Our use of weekly data differs with the studies by Koontz, Garcia and Hudson (1993), which used daily price data, Stiegert, Azzam and Brorsen (1993), which used quarterly data, and Carlberg, Hogan and Ward (2009), which used transaction data from a simulated market. We believe that use

Table 1 Descriptive statistics of data variables

	Variable	mean	std. dev.	min	max
2001-2010	slaughter (1,000 head)	524.11	46.50	352.6	656.8
(477 observations)	cof_{-1} (1,000 head)	10,972.73	629.13	9590	12,110
	p_{corn} ($/bu)	2.78	0.78	1.88	6.10
	p_{alpha} ($/ton)	101.51	14.88	80.85	147.01
	plc_{-4} (1,000 head)	1,946.83	318.36	1,391	2788
	plc_{-5} (1,000 head)	1,948.33	323.12	1,391	2,788
	plc_{-6} (1,000 head)	1,961.03	327.30	1,391	2,829
	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	slaughter (1,000 head)	525.11	43.61	365.5	624.73
(348 observations)	cof_{-1} (1000 head)	7,883.37	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)	1,611.08	355.50	1,068	2,536
	plc_{-5} (1000 head)	1,602.64	348.26	1,068	2,536
	plc_{-6} 1000 head)	1,596.31	343.17	1,068	2,536
	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

of weekly data represents the most appropriate interval for examining switching patterns in the pricing for U.S. fed cattle. From a practical standpoint, the buyers of fed cattle operate in a weekly market. Bid and ask prices are conducted through the week and there is a window during the week where almost all transactions take place. Under these institutional patterns, much of the price volatility within a week may represent short-term price changes that have little to do with regime switching. Weekly average prices mitigate such daily price noise, which should allow for better identification of switching events. Using monthly or quarterly data opens up the possibility that switching events cannot be easily identified due to aggregating over such longer time periods.

We estimated the beef packer margins model with a Markov switching specification using MSVARlib developed by Bellone (2005). The margin model estimates are reported in table 2. 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 their variables to construct a predicted value for the marginal processing cost variable is illustrative. The predicted marginal processing costs correlate strongly with the actual marketing margin and explain, on average, over 90% of the actual marketing margins in both samples.

The lower portion of table 2 contains the regime-dependent parameters and duration results for the MPR years and the pre-MPR years. For the MPR years, all the regime-dependent parameter estimates except β_1 are statistically significant, and all the estimates are statistically different than

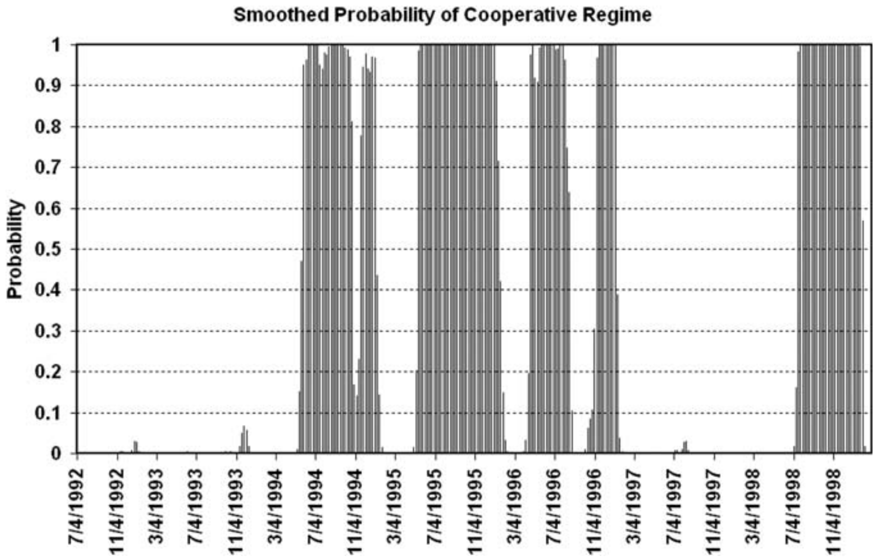
Table 2. Maximum likelihood estimates of Markov regime switching model

	Parameters	2001-2010		1992-1999		
		estimate	**std. dev.**	**estimate**	**std. dev.**	**difference**
Regime-independent	γ_1	0.407***	(0.132)	-3.205***	(0.975)	3.612***
	γ_2	-1.560**	(0.803)	-1.493***	(0.530)	-0.067
	γ_3	-0.068	(0.239)	2.999***	(0.875)	3.067***
	γ_4	-0.235	(0.212)	0.731	(0.545)	0.966***
	γ_5	1.273**	(0.634)	-0.358	(0.370)	1.631***
Regime-dependent	p	0.933***	(0.020)	0.973***	(0.011)	-0.040***
	q	0.951***	(0.015)	0.946***	(0.022)	0.005***
	β_1	-0.007	(0.067)	0.180***	(0.056)	-0.187***
	β_2	0.155***	(0.062)	0.223***	(0.071)	-0.068***
	κ_1	-0.752***	(0.053)	-0.516***	(0.035)	-0.236***
	κ_2	0.544***	(0.059)	0.922***	(0.075)	-0.378***
	ρ_1	0.288***	(0.033)	0.194***	(0.020)	0.094***
	ρ_2	0.610***	(0.056)	0.496***	(0.066)	0.141***
Expected duration†	Noncooperative	14.93 weeks (42.3%)		37.04 weeks (66.7%)		-22.1***
	Cooperative	20.41 weeks (57.7%)		18.52 weeks (33.3%)		1.9***
Log-likelihood		-541.88		-304.11		

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

† Numbers in parentheses reflect the average percentage of weeks in each regime.

Figure 1 Probability of cooperative regime, July 1992 – February 1999



(Shaded regions identify periods of cooperative regime)

the pre-MPR years.[4] The conditional probability of remaining in the non-cooperative regime (p) is 0.933 during MPR and 0.973 pre-MPR. This parameter is used to calculate the expected duration of remaining in a non-cooperative state: 14.93 weeks during MPR and 37.04 weeks pre-MPR.[5] The conditional probabilities for the cooperative regimes (q) imply that expected duration has increased from 18.52 weeks pre-MPR to 20.41 weeks during MPR. Our findings show that, in the post-MPR period, beef packers were able to successfully switch out of the non-cooperative regimes much faster than in the pre-MPR period. This ability to switch in the latter period has a significant impact on the average number of weeks that beef packers end up in the cooperative state. Specifically, our results suggest that packers cooperate in 33.3% of the weeks in the pre-MPR period and 57.7% of the weeks during MPR.[6]

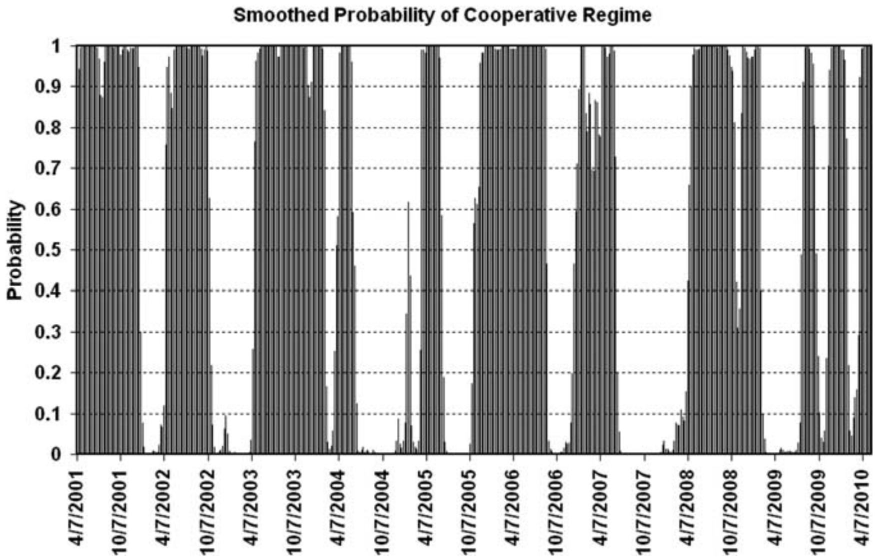
Several other regime-dependent coefficients provide useful insights about the U.S. beef market. The next two regime-dependent parameters (β_1 and β_2) are measures of the degree of oligopsony power in the non-cooperative and cooperative regime. β_1 is statistically insignificantly different from zero in the 2001-2010 period, but is statistically significant in the pre-MPR years. Thus, we describe the non-cooperative regimes when MPR was active as being perfectly competitive. As we will show later, the oligopsonistic rents during the non-cooperative regimes in the pre-MPR period are quite small. The regime-dependent constant coefficients, κ_1 and

[4]*We first conducted the equal variance test with F-statistics, and then we tested whether the coefficients from two sample years are equal to each other based on the t-statistics.*

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

[6]*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 between 40-80% of the time.*

Figure 2 Probability of cooperative regime, April 2001 – May 2010



(Shaded regions identify periods of cooperative regime)

Table 3 Percentage of margin variation in the switching weeks, 2001-2010

Week	% Change	Week	% Change
4/7/2001	–	12/30/2006	−12.54
12/29/2001	−31.35	6/16/2007	−19.38
4/13/2002	116.44	4/12/2008	26.93
10/19/2002	−34.91	10/25/2008	−36.38
4/19/2003	28.59	11/15/2008	173.31
2/14/2004	−47.44	2/7/2009	−40.55
4/10/2004	63.41	8/1/2009	100.59
6/19/2004	−27.90	10/3/2009	−21.11
3/19/2005	104.44	11/14/2009	35.72
6/18/2005	−21.11	2/6/2010	−29.82
11/19/2005	82.09	4/3/2010	119.61
9/2/2006	−70.14		

Rows highlighted in gray represent switches into the cooperative regime.
Rows not highlighted represent switches into non−cooperative regimes.
Percentage change results are from $(m_t - m_{t-1})/ m_{t-1}$.

$\sum_{\lambda=1}^{\infty} \lambda q^{\lambda-1}(1-q) = (1-q)^{-1}$, are statistically significant and quite different in magnitude. These parameters describe the intercept of the margin model during the two phases and capture the unexplained marginal cost factors in margin equation (2). During the non-cooperative phases, κ_1 is considerably negative and during the cooperative phases κ_2 is positive. The estimates of regime-dependent variances, ρ_1 and ρ_2, are significant and vary across regimes. These findings suggest that each regime operates quite differently, and the larger variances since 2001 help explain why switching is more common in the post-MPR period.

Table 4 Average margin results for cooperative and noncooperative regimes

Years	2001-2010	1992-1999
Average cooperative margin	14.91 ($/cwt)	7.87 ($/cwt)
Average non-cooperative margin	7.71 ($/cwt)	2.29 ($/cwt)
Difference	7.20 ($/cwt)	5.58 ($/cwt)
Market power (% of cooperative margin)	4.02%	2.91%
Annual average economic profit	$90.01 million†	$25.01 million‡
Market power (% of non-cooperative margin)	0%	1.13%
Annual average economic profit	$0 million†	$5.65 million‡
Total annual average economic profit	$90.01 million†	$30.66 million‡
Average per head economic profit	$2.59†	$0.88‡

† *Reported values are in 2001 dollars.*
‡ *Reported values adjusted to 2001 dollars: $1 in 1992 = $1.26 in 2001.*

Using Hamilton's (1989) filter technique for determining each regime switch, we can also present our findings graphically. Figures 1 and 2 show the inferred probabilities of being in each regime each week during MPR and pre-MPR, respectively. The unshaded regions represent the weeks in the non-cooperative regime and the shaded regions represent weeks in the cooperative regime.[7] Comparing the two figures shows that since MPR, the market was in a cooperative state many more weeks than in the pre-MPR period. There are 12 cooperative periods between April 2001 and May 2010. One of the longest cooperative periods 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, a pattern of cooperative pricing was developing, along with short intermittent breakdowns.

In table 3, we report the percentage change in the margin during the week of each regime change since MPR was implemented (see Cai, Stiegert, and Koontz (2011) for a similar analysis of the 1992-1999 period). As in figure 2, the switches to each non-cooperative regime are in the unshaded rows, and the switches to the cooperative regime appear in the shaded rows. During all 11 weeks that the market switched to non-cooperative pricing, beef packing margins dropped by 20% or more. In all but two of the switches to the cooperative regime, beef packing margins increased by at least 27% and in some cases, changes were over 100%. These results appear quite reasonable; we find a strong association of sizable increases or decreases in the margin with switching into cooperative and non-cooperative regimes, respectively.

Using the inferred probabilities that defined each regime in figures 1 and 2, the first three rows of table 4 present a comparison of the average calculated marketing margins. The marketing margins and difference between regimes are much wider from 2001-2010 compared to 1992-1999. This is not, per se, 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

[7] *In a slight departure from Hamilton (1989), in this study beef packers are considered to be in the cooperative regime when Prob[$S_t = 2$] $\gt $ 0.6, and in the non-cooperative regime when P[$S_t = 1$] $\gt $ 0.6. A probability between 0.4 and 0.6 indicates neither a cooperative regime nor non-cooperative regime. In this way, a buffer band is provided to ensure switching is complete.*

measure the share of the regime-dependent marketing margin associated with oligopsony power, which implicitly accounts for marginal processing costs. For this reported result, we estimate the percent of marketing margin associated with market power for each week throughout the study. Using the inferred probabilities that defined each regime in figures 1 and 2, we then calculate the simple average for each regime. The share of margin associated with oligopsony power in the cooperative regime is higher during MPR (4.02%) compared to the pre-MPR sample (2.91%). In the non-cooperative regimes, market power is not present during MPR (0.0%) and quite small pre-MPR (1.13%). Using simple calculations and recognizing the average number of weeks that the market is in each regime, we find that gains due to operating in the cooperative regime during MPR amount to approximately $90.01 million 2001 dollars of additional economic profit each year, or $2.59 per head.[8] These numbers compare to 30.66 million 2001 dollars ($0.88/head) of additional economic profit in the pre-MPR period. The annual economic profits accrued in the beef packing industry during MPR is about three times the annual average economic profit accruing during the 1990s.

The increase in oligopsony power exercised through pricing behavior is clear. The argument that it is due to MPR requires some caveats. In one sense, we were 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. We view it as unlikely that MPR provided packers with much information that they did not already have. Nonetheless, our results are quite consistent with concerns expressed by Wachenheim and Devuyst (2001). We also recognize that we are not directly testing the impact of MPR on oligopsony power. Our approach is the same as all event studies or studies based on dummy variables in that we 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 degree of 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 oligopsony power, then, in oligopsonistic settings, information is a double-edged sword, and in the beef packing industry it appears to favor greater levels of coordination. This would clearly be an unintended consequence of the MPR legislation. When comparing the two time periods in our study, the single largest change that drives our results comes in the shorter duration of non-cooperative periods after MPR was implemented. In other words, the beef packers have increased economic profits since MPR, principally because they did a better job staying out of the non-cooperative regimes. Additional research is warranted to look at how MPR might assist beef packers in making the transition from non-cooperative to cooperative regimes.

[8] *Since 1990, annual beef production in the U.S. was between 24.5 and 27 billion pounds. So for 26 billion pounds of production and operating in the cooperative regime 57.76% of the time, the additional profit to the industry is: (26 billion pounds)/100*(14.91*0.0402)*0.5776 = $90.01 million. On a per head basis, a reasonable fed animal carcass weight was 750 pounds. So (7.5 cwt per head)*(14.91*0.0402)*0.577 = $2.59 per head.*

Conclusion

High levels of concentration and the associated oligopsony power in the U.S. beef packing industry have been a major public policy concern for many decades. One possible way to mitigate oligopsony power is to provide market participants with more information. In 1999, the Livestock Mandatory Price Reporting Act was passed, which was aimed to increase fed cattle price transparency and provide more information to the cattle producers. Price reporting under this act began in April of 2001. In this article, we empirically evaluated the competitive conditions of the U.S. fed cattle procurement market before and after the implementation of MPR. Using a regime-dependent switching regression model, our objective was to determine if the MPR goals of price transparency could be associated with a more competitive procurement market. Identical models are estimated using weekly marketing margin data in a pre-MPR period (July, 1992-February, 1999), and after MPR went into effect (April, 2001-May, 2010). Our empirical results provide evidence that the switching regression model is a good representation of the data-generating process for beef packer margins in both time periods. Evidence of regime switching implies that cattle procurement markets were not perfectly competitive either before or after implementing MPR.

One motive for implementing MPR was based on a foundation of thought that greater market transparency will make it more difficult for beef packers to tacitly collude. In other words, MPR could generate a pro-competitive gain for cattle feeders. However, as suggested by several economists (Wachenheim and DeVuyst 2001; Azzam 2003; Njoroge 2003; and Njoroge et al. 2007), MPR could also be used by packers as a facilitating mechanism to extend their oligopsony power, leading to lower prices for live cattle. The object of our study design was to provide evidence about the degree of oligopolistic pricing prior to the MPR announcement in 1999 and after its implementation in 2001.

Like many event studies or studies that evaluate a single policy shift using a dummy variable, one cannot easily assign a statistical claim about the impact of the change. The problem is that other factors that correlate with the policy shift might be causing all or part of the impact thought to be due to the policy. Since we face the same dilemma, we needed to be careful in interpreting the results. Throughout the paper, we discussed the statistically significant findings from each estimation in terms of before/after MPR implementation. However, we do not claim to identify a statistically significant causal relationship between MPR and the changes in oligopsonistic pricing. Our findings should be classified as offering empirical support for or against the opposing theoretical claims about what MPR has provided to the market.

The research resulted in several key findings. First, the findings about general support for the switching regression model have widespread implications for researchers examining this industry. Much of the previous research on the meat packing industry has looked to define market power in a static setting that presumes the market essentially functions in a single regime. Our results suggest that those studies are mis-specified in ways that lead to incorrect assessments of conduct and imprecise claims about the associated welfare losses.

Second, compared to the 1990s, we provide clear statistical evidence that oligopsony power has substantively increased since 2001. On a per head basis, we estimate that average economic profit due to oligopsony power has risen from $0.88/head in the 1990s to approximately $2.59/head in the period after 2001. Our results are consistent with concerns from economists that the market transparency features of the MPR Act will not generate much of a pro-competitive impact, and may serve as a facilitating tool for beef packers to increase market power.

Finally, our study finds that the primary source of economic profits since MPR was implemented was derived from beef packers' ability to more effectively switch out of the non-cooperative regimes. Specifically, beef packers decreased their time in the non-cooperative regimes from 57.7% in the 1990s to only 33.3% after 2001. Could switching out of bad outcomes be the way in which MPR helps beef packers? Given that switching conduct requires good information about competing bids, this would be a good area for further research.

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Appendix: Discussion and Results from the Auxiliary Slaughter Model

The purpose of the exercise described in this appendix is to obtain an estimate for anticipated supply of live cattle $\hat{y}_t$. The model we estimate is given by:

$$\begin{aligned} y_t =& \alpha + \alpha_1 y_{t-1} + \alpha_2 \text{cof}_1 + \alpha_3 p_c + \alpha_4 p_a + \sum_{i=5}^{7} \alpha_i \text{plc}_{i-1} \\ &+ \sum_{i=8}^{18} \alpha_i D_i + \alpha_{19} \text{BSE}_i + \sum_{i=20}^{25} \alpha_i \text{CBSE} + e_t \text{ where } e_t = \rho e_{t-1} \end{aligned} \quad (A1)$$

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.

There were two BSE (Bovine Spongiform Encephalopathy) incidents that occurred during the post-MPR years. In May 2003, BSE was discovered in Canada and the trade of fed cattle to the U.S. halted; in December 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 of the two BSE incidents on the supply of cattle in the U.S. These variables are not present in the 1992-1999 model and are included only in the 2001-2010 model. Specifically, the variable BSE is one for the weeks between December 24, 2003 and April 10, 2004, and zero elsewhere. Exports of Canadian fed cattle were prohibited between May 20, 2003 and July 18, 2005. To capture the impact of Canadian exports of live cattle into the U.S., we note that Canada's largest seasonal slaughter occurs in the first and fourth quarters of the year. We therefore interact a Canadian BSE dummy variable (equal to one during the export ban) with the monthly dummies for the first and last quarters of the year (variable name is CBSE).

The results for the two fed cattle slaughter volume models are reported in table A1. The coefficient on slaughter volume lagged one week was highly significant and is the most important variable in the model in terms of contributing to the explanation of the variation in weekly slaughter volume. 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 the post MPR model; they are included to demonstrate that 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 CBSE terms, 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 were not available.

Table A1 Estimates of auxiliary slaughter 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)		
ρ	-0.11		-0.15	
R^2	0.69		0.68	
Adjusted R^2	0.67		0.66	
RMSE	28.96		28.06	

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