An Empirical Analysis of Pricing in the U.S. Beef Industry

Yuliya V. Bolotova

A former Assistant Professor of Agribusiness
Department of Agricultural Sciences
College of Agriculture, Forestry and Life Sciences
Clemson University
Clemson, SC 29634
E-mail: yuliyab@g.clemson.edu

Abstract

The U.S. beef packing industry has historically raised competition concerns related to marketing and pricing of cattle and beef. In 2019 cattle producers, a meat wholesaler and consumers filed class action antitrust lawsuits alleging that the four largest beef packers in the country unlawfully conspired to decrease fed cattle prices and to increase wholesale and retail prices of beef and thus violated Section 1 of the Sherman Act. The supply restraints are claimed to be the primary method of implementing this price-fixing conspiracy. The research presented in the paper conducts an econometric analysis of wholesale and retail price behavior in the U.S. beef industry during the period of alleged cartel of the four largest beef packers and the prior (more competitive) period. The empirical evidence on wholesale price behavior indicates a shift from a perfectly competitive pricing of beef packers (wholesalers) during a more competitive period to an oligopoly/monopoly pricing during the alleged cartel period. The empirical evidence on retail price behavior indicates that the pricing of food retailers was consistent with oligopoly pricing during both periods of interest.

Key words: antitrust, beef industry, buyer market power, cartels, margins, price-fixing, seller market power, Sherman Act, supply restraints.

1. Introduction

The U.S. beef packing industry has historically raised competition concerns related to marketing and pricing of fed cattle and beef products throughout the beef supply chain (Hahn 1991, 2002; Azzam 1998; Mathews et al 1999; Hahn and Nelson 2002; Taylor 2002; Ward 2010; Congressional Research Service Report 2009; Greene 2016). The process of increasing consolidation and concentration, which affected the U.S. beef packing industry during recent decades, led to a smaller number of larger firms controlling fed cattle slaughtering and beef processing stages of the beef supply chain (Johnson 2009). Since approximately 1993, the four largest beef packers have been slaughtering approximately 80% of fed cattle raised by cattle producers (Green 2016).

The U.S. fed cattle price dynamics during the last several years attracted increased attention of industry participants and policy decision makers (U.S. Government Accountability Office Report 2018). During the period of 2010 - 2015, fed cattle prices, while being volatile, were steadily increasing from approximately $90 per cwt at the beginning of 2010 to approximately $170 per cwt by the end of 2014. In 2015, fed cattle prices collapsed, decreasing to approximately $125 per cwt by the end of 2015 and further to $100 per cwt by the end of 2016 (U.S. Government Accountability Office Report 2018, Figure 4).

In April of 2019, Ranchers Cattlemen Action Legal Fund United Stockgrowers of America (R-CALF) and several fed cattle producers filed a class action antitrust lawsuit alleging that the four largest beef packers in the country, Tyson Foods, JBS USA, Cargill and National Beef Packing Company, engaged in anticompetitive conduct, which restricted competition in the market for fed cattle and violated Section 1 of the Sherman Act, Packers and Stockyards Act and Commodity Exchange Act (Stempel 2019; Welshans 2019). R-CALF and fed cattle producers alleged that these firms unlawfully conspired to fix, decrease and stabilize fed cattle prices paid to fed cattle producers as early as January 2015.

Later in 2019, consumers purchasing beef products at the retail level (indirect buyers) and a meat wholesaler purchasing beef products directly from the beef packers (a direct buyer) filed class action antitrust lawsuits against the same companies alleging that they engaged in a price-fixing conspiracy with the purpose of fixing, increasing and stabilizing beef product prices as early as January 2015, and thus violated Section 1 of the Sherman Act (Brown 2019; Douglas 2019).

The fed cattle producers and beef buyers argue that the supply restraints (the reduced slaughter rates, plant capacity underutilization and plant closures, among others) were the primary method of implementing these price-fixing conspiracies. It is argued that the beef packers collectively decreased the quantity of fed cattle purchased, which decreased the quantity of beef products produced and sold and consequently decreased fed cattle prices and increased beef prices at the wholesale and retail levels. This is a cartel-type conduct, involving exercise of buyer and seller market power by the same firms, which may violate Section 1 of the Sherman Act.

The research objective is to conduct an econometric analysis of wholesale and retail price behavior in the U.S. beef industry during the period of alleged cartel of the four largest beef packers and the prior (more competitive) period. The paper is organized as follows. Section 2 describes data and presents descriptive statistical analysis of prices, marketing margins and farm sector share in the U.S. beef supply chain during the two periods of interest. Section 3 presents economic model of a vertical price transmission used to develop econometric models of wholesale and retail price behavior. Section 4 describes econometric models and hypotheses. The focus of econometric analysis is on estimating cost pass-throughs, which can be used to distinguish between perfectly competitive pricing and imperfectly competitive pricing (the case of seller market power) of beef packers (wholesalers) and food retailers. Section 5 presents the results of econometric analysis, and it is followed by the conclusion. This paper extends the research presented in Bolotova (2020), which analyzes the most recent competition issues in the U.S. beef industry.

2. Data and Descriptive Statistical Analysis

The empirical analysis is conducted using data available in the U.S. Department of Agriculture Economic Research Service (USDA ERS) publicly available databases. The farm, wholesale and retail values of beef are from *Historical Price Spread Data for Beef, Pork, Broilers* (USDA ERS 2020)[1]. The farm, wholesale and retail values of beef used in the analysis are proxies for prices at the farm, wholesale and retail levels of the beef supply chain. The differences between these values are marketing margins: farm-to-wholesale margin, wholesale-to-retail margin and farm-to-retail margin.

Table 1 summarizes monthly averages and coefficients of variation for farm, wholesale and retail values of beef, corresponding margins and farm sector share during the two periods of interest. These are the period of alleged anticompetitive conduct of the four largest beef packers, "cartel period" to be referred to in the paper (2015-2019), and the prior period, "pre-cartel period" to be referred to in the paper (2010-2014)[2]. This table also presents changes in the averages and coefficients of variation between these two periods. The beef values are used to calculate farm-to-wholesale margin, wholesale-to-retail margin and farm sector share. Farm-to-wholesale margin is the difference between wholesale value of beef and farm value of beef; it includes wholesale (slaughtering and processing) costs and profit of beef packers (wholesalers). Wholesale-to-retail margin is the difference between retail value of beef and wholesale value of beef; it includes costs and profit of retailers.

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[1] USDA ERS collects prices corresponding to different levels of the beef supply chain (farm, processing plant (wholesale) and retail) and uses these prices to calculate farm value of beef, wholesale value of beef and retail value of beef and the differences between these values (price spreads): farm-to-wholesale price spread, wholesale-to-retail price spread and farm-to-retail price spread (Hahn 1991 and 2004). The farm and wholesale values are converted into a retail-weight equivalent. Therefore, price spreads are adjusted for the value of by-products and the weight loss, as animals move throughout the beef supply chain and are transformed into retail beef cuts. The price spreads are referred to as marketing margins in this paper.
[2] The year of 2015 distinguishes these two periods, because as it is stated in the complaints the allegedly anticompetitive conduct of the beef packers began in 2015 and continued until "present" (the moment the complaints were filed in 2019; the lawsuits are still pending). The period of 2015-2019 is selected as cartel period. The period of 2010-2014 is selected as pre-cartel period, because it has the same length as cartel period. An alternative (longer) pre-cartel period was used in the preliminary analysis: 2000-2014. The length of pre-cartel period did not affect significantly the empirical patterns. The descriptive statistics for the alternative pre-cartel period are summarized in the Appendix.

The farm-to-wholesale margin, wholesale-to-retail margin and farm sector share are expressed as a percentage of the retail value. The farm-to-wholesale margin is also expressed as a percentage of the wholesale value. Figure 1 depicts monthly farm, wholesale and retail values of beef. Figure 2 depicts the yearly farm sector share, farm-to-wholesale margin and wholesale-to-retail margin, all expressed as a percentage of the retail value of beef[3].

Pre-cartel period (2010-2014)

During pre-cartel period, the monthly average farm value, wholesale value and retail value of beef are $2.60 per pound, $2.94 per pound and $5.09 per pound, respectively. The monthly average farm-to-wholesale margin and wholesale-to-retail margin are $0.34 per pound and $2.15 per pound, respectively. Expressed as a percentage of the retail value, the monthly average farm sector share, farm-to-wholesale margin and wholesale-to-retail margin are 50.77%, 6.78% and 42.44%, respectively. Expressed as a percentage of the wholesale value, the farm-to-wholesale margin is 11.83%.

Cartel period (2015-2019)

During cartel period, the monthly average values of beef and margins increase, but the monthly average farm sector share decreases. The rate of the farm value increase (5.4%) is smaller than the rate of the wholesale and retail value increases (13.6% and 18.3%, respectively). The rate of the farm-to-wholesale margin increase is higher than the rate of the wholesale-to-retail margin increase. The farm-to-wholesale margin measured in monetary units increases by 76.7%. This margin measured as a percentage of the wholesale value increases by 53.2%, and this margin measured as a percentage of the retail value increases by 47.6%. The wholesale-to-retail margin measured in monetary units increases by 24.7%, and this margin measured as a percentage of the retail value increases by 5.1%. The farm sector share measured as a percentage of the retail value decreases by 10.6%.

During cartel period, the monthly average farm value, wholesale value and retail value of beef are $2.74 per pound, $3.34 per pound and $6.03 per pound, respectively. The monthly average farm-to-wholesale margin and wholesale-to-retail margin are $0.60 per pound and $2.68 per pound, respectively. Expressed as a percentage of the retail value, the monthly average farm sector share, farm-to-wholesale margin and wholesale-to-retail margin are 45.39%, 10.02% and 44.59%,

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[3] The sum of farm sector share, farm-to-wholesale margin and wholesale-to-retail margin (all expressed as a percentage of the retail value) is equal to 100%.

respectively. Expressed as a percentage of the wholesale value, the farm-to-wholesale margin is 18.12%.

While the wholesale value of beef and farm-to-wholesale margin increases are substantial in cartel period, as compared to pre-cartel period, the magnitude of the farm-to-wholesale margin is the smallest, as compared to the farm sector share and the wholesale-to-retail margin. The farm-to-wholesale margin measured as a percentage of the retail value increased from 6.78% in pre-cartel period to 10.02% in cartel period, or by 3.2%-points (47.6%). The wholesale-to-retail margin measured as a percentage of the retail value increased from 42.44% in pre-cartel period to 44.59 in cartel period, or by 2.1%-points (5.1%). The farm sector share decreased from 50.77% in pre-cartel period to 45.39% in cartel period, or by 5.4%-points (10.6%). The farm-to-wholesale margin measured as a percentage of the wholesale value increased from 11.83% in pre-cartel period to 18.12% in cartel period, or by 6.3%-points (53.2%).

As indicated by changes in the coefficients of variation, the farm, wholesale and retail values of beef and wholesale-to-retail margin measured in monetary units are less volatile in cartel period, as compared to pre-cartel period. Farm-to-wholesale margin measured in monetary units and as a percentage of the retail value, wholesale-to-retail margin measured as a percentage of the retail value, and farm sector share measured as a percentage of the retail value are more volatile in cartel period, as compared to pre-cartel period.

3. Economic Model

The economic model of a vertical price transmission is a relevant theoretical framework used as a foundation for econometric analysis of wholesale and retail beef price behavior. The focus is on two price relationships: the relationship between wholesale price (a revenue element for beef packers) and farm price (a cost element for beef packers), and the relationship between retail price (a revenue element for food retailers) and wholesale price (a cost element for food retailers). The vertical price transmission mechanism reflects cost pass-through, which magnitude can be used to distinguish between a perfectly competitive pricing and an imperfectly competitive pricing (seller market power: oligopoly and monopoly) and to characterize pricing practices (methods) used by beef packers (wholesalers) and food retailers[4].

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[4] A comprehensive discussion of cost pass-through in light of imperfectly competitive pricing and antitrust issues is presented in Harris and Sullivan (1979), Cotterill (1998), Cotterill et al (2001),

Equation [1] represents a linear price transmission process. The output price *P output* (downstream price) is specified as a linear function of the input price *P input* (upstream price).

[1] *P output = a + b*P input*.

Two price transmission processes are analyzed in this research: farm-to-wholesale price transmission process represented by equation [1.1] and wholesale-to-retail price transmission process represented by equation [1.2].

[1.1] *Wholesale Price = a_1 + b_1*Farm Price*.

[1.2] *Retail Price = a_2 + b_2*Wholesale Price*.

In equation [1], *a* is a non-negative constant, which is also referred to as fixed absolute markup, and *b* is a vertical price transmission coefficient, which is also referred to as cost pass-through (CPT). The CPT indicates a $ per unit increase (decrease) in the output price, which follows a $1 per unit increase (decrease) in the input price. CPT in equation [1.1] is farm-to-wholesale price transmission coefficient (b_1). CPT in equation [1.2] is wholesale-to-retail price transmission coefficient (b_2).

Given that marketing margin (*Margin*) is the difference between output price and input price: [2] *Margin = P output – P input*,

substituting [1] into [2] yields the identity for marketing margin:

[3] *Margin = a + (b-1)*P input*.

The magnitude of the coefficients in equations [1] and [3] provides evidence on pricing methods used by wholesalers and retailers. The magnitude of *b=1* (complete cost pass-through) and *a>0* would reflect a fixed absolute markup pricing method consistent with perfect competition characterized by a "sticky" margin (*Margin = a*). In the case of imperfectly competitive pricing (seller market power: oligopoly and monopoly), two special cases can be considered: *b<1* and *b>1*.

If a profit-maximizing monopolist operates in a market environment with linear demand and constant marginal cost, the magnitude of *b* is equal to 0.5 (incomplete cost pass-through). The first-order profit-maximization condition for this monopolist can be rearranged to express its output price as a function of marginal cost (input price): *P = 0.5 + 0.5*MC*. The constant *a* is non-negative in this case. A profit-maximizing oligopoly in a similar market environment would yield

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Kosicki and Cahill (2006), and RBB Economics (2014). A detailed analysis of the types of wholesale pricing methods is presented in George and King (1971).

8

the magnitude of *b* in the range from 0.5 (monopoly) to 1 (perfect competition). The output price stabilization method is consistent with pricing predicted by these economic models.

In the case of a profit-maximizing monopoly and a profit-maximizing oligopoly operating in a market environment with non-linear (convex) demand and constant marginal cost, the magnitude of *b* is greater than 1 (more than a complete cost pass-through). The oligopoly cost pass-through is greater than one and is smaller than the monopoly cost pass-through. The first-order profit-maximization conditions (FOC) for monopoly and oligopoly are:

$$P = \left(\frac{1}{1 + \frac{1}{\eta}} \right) \times MC \ \text{ and } \ P = \left(\frac{1}{1 + \frac{1}{N \times \eta}} \right) \times MC, \text{ respectively } (\eta_{Q,P} = \frac{dQ}{dP} \times \frac{P}{Q} < 0 \text{ is the market}$$

demand elasticity, and *N* is the number of firms in the case of oligopoly). The constant *a* is equal to zero. The terms in the parentheses (cost pass-throughs) must be greater than one for output price to exceed marginal cost[5]. Introducing *N* in the FOC for oligopoly decreases the magnitude of cost pass-through, as compared to the monopoly case. The fixed percentage markup pricing method is consistent with pricing predicted by these economic models; this pricing method reflects the marketing margin stabilization strategy.

The behavior of marketing margin is conditional on the magnitude of cost pass-through. If *b=1* (a perfect competition case), the margin is constant: *Margin = a* in equation [3]; the margin does not respond to changes in the input price in this case. If *b>1* or *b<1* (an imperfect competition case: seller market power), the margin responds to changes in the input price. In the case of incomplete cost pass-through (*b<1*), the margin decreases (increases), given an input price increase (decrease). In the case of more than a complete cost pass-through (*b>1*), the margin increases (decreases), given an input price increase (decrease). Therefore, the margin response to the same change in the input price is different under the two presented scenarios of imperfectly competitive pricing.

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[5] The cost pass-through is greater than one, if the absolute value of market demand elasticity is greater than one (monopolist and oligopolists price on the elastic region of market demand curve, in which case marginal revenue is positive).

4. Econometric Models and Hypotheses

The objective of the econometric analysis is to evaluate whether there are changes in the wholesale and retail price behavior and associated price transmission processes in the U.S. beef supply chain between the pre-cartel period (2010-2014) and cartel period (2015-2019). The focus is on evaluating the magnitude and statistical significance of the fixed absolute markups (FAMs) and cost pass-throughs (CPTs) in the two analyzed periods as well as changes in FAMs and CPTs between these two periods.

The econometric model of wholesale beef price behavior is represented by equation [4]. The econometric model of retail beef price behavior is represented by equation [5]. Both econometric models are specified as linear regression models[6].

[4] $WP_t = \alpha_0 + \beta_0 FP_t + \alpha_1 C_t + \gamma_0 FP_t C_t + \theta M_t + \varepsilon_t$

In equation [4], WP_t and FP_t are wholesale value and farm value of beef, respectively, in month t. Both values are measured in cents per pound. C_t is a binary variable (intercept shifter); it is equal to one, if a wholesale value observation belongs to cartel period (2014-2019), and it is equal to zero otherwise. The reference group is represented by wholesale value observations belonging to pre-cartel period (2010-2014). $FP_t C_t$ is the interaction effect of the farm value and cartel binary variable (slope shifter). M_t is a set of monthly binary variables. ε_t is the error term.

[5] $RP_t = \alpha_0 + \beta_0 WP_t + \beta_1 WP_{t-1} + \beta_2 WP_{t-2} + \alpha_1 C_t + \gamma_0 WP_t C_t + \gamma_1 WP_{t-1} C_t + \gamma_2 WP_{t-2} C_t + \theta M_t + \varepsilon_t$

In equation [5], RP_t and WP_t are retail value and wholesale value of beef, respectively, in month t. Both values are measured in cents per pound. WP_{t-1} and WP_{t-2} are the first and the second lag of the wholesale value. C_t is a binary variable (intercept shifter); it is equal to one, if a retail value observation belongs to cartel period (2014-2019), and it is equal to zero otherwise. The reference group is represented by retail value observations belonging to pre-cartel period (2010-2014). $WP_t C_t$, $WP_{t-1} C_t$ and $WP_{t-2} C_t$ are the interaction effects of the current and lagged wholesale values and cartel binary variable (slope shifters). M_t is a set of monthly binary variables. ε_t is the error term.

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[6] The number of lagged prices to be included as independent variables in the econometric models is determined using alternative specifications of these models based on different lag structures and statistics used to evaluate the performance of econometric models (Akaike Information Criterion and Schwarz Criterion).

Each econometric model has 60 observations. Both econometric models are estimated using the Ordinary Least Squares (OLS) estimation procedure.

Table I presented below provides the interpretation of constants and coefficients in the econometric models representing the price functions. In light of the theoretical framework, the constants are fixed absolute markups (FAM), and the coefficients are cost pass-throughs (CPT).

Table I. Interpretation of Constants "Fixed Absolute Markups" (FAM) and Coefficients "Cost Pass-Throughs" (CPT) in the Beef Price Functions: Equations [4] and [5].

Pre-cartel period	Cartel period
Wholesale price function: CPT is farm-to-wholesale price transmission coefficient	
α_0 is FAM	$(\alpha_0+\alpha_1)$ is FAM
	α_1 is the difference in FAM between the cartel and pre-cartel periods
β_0 is current month CPT	$(\beta_0+\gamma_0)$ is current month CPT
	γ_0 is the difference in current month CPT between the cartel and pre-cartel periods
Retail price function: CPT is wholesale-to-retail price transmission coefficient	
α_0 is FAM	$(\alpha_0+\alpha_1)$ is FAM
	α_1 is the difference in FAM between the cartel and pre-cartel periods
β_0 is current month CPT	$(\beta_0+\gamma_0)$ is current month CPT
	γ_0 is the difference in current month CPT between the cartel and pre-cartel periods
$(\beta_0+\beta_1+\beta_2)$ is cumulative CPT	$(\beta_0+\beta_1+\beta_2+\gamma_0+\gamma_1+\gamma_2)$ is cumulative CPT
	$(\gamma_0+\gamma_1+\gamma_2)$ is the difference in cumulative CPT between the cartel and pre-cartel periods

Table II presented on the next page summarizes the null and alternative hypotheses for T-tests on the magnitude of constants (fixed absolute markups) and estimated coefficients (cost pass-throughs) during the analyzed periods.

Table II. T-Tests on the Magnitude of Fixed Absolute Markups (FAM) and
Cost Pass-Throughs (CPT): The Null and Alternative Hypotheses.

Hypotheses on the magnitude of fixed absolute markup Ho: FAM = 0 and Ha: FAM > 0
Hypotheses on the CPT magnitude*: a perfectly competitive pricing case Ho is perfectly competitive pricing (complete CPT) Ha is imperfectly competitive pricing (more than complete CPT: monopoly or oligopoly in a market with non-linear demand and constant marginal cost) Ho: CPT = 1 and Ha: CPT > 1
Hypotheses on the CPT magnitude: an imperfectly competitive pricing case #1 Ho is monopoly pricing in a market with linear demand and constant marginal cost (incomplete CPT) Ha is oligopoly pricing in a market with linear demand and constant marginal cost (incomplete CPT) Ho: CPT = 0.5 and Ha: CPT > 0.5
Hypotheses on the CPT magnitude: an imperfectly competitive pricing case #2 Ho is oligopoly pricing in a market with linear demand and constant marginal cost (incomplete CPT) Ha is monopoly pricing in a market with linear demand and constant marginal cost (incomplete CPT) Ho: CPT = 0.75** and Ha: CPT < 0.75

* The CPTs used to conduct T-tests in the wholesale price model are the current month CPTs. The CPTs used to conduct T-tests in the retail price model are the cumulative CPTs. The CPTs and FAMs for pre-cartel and cartel periods are explained in Table I.

** In a market with linear demand and constant marginal cost, the oligopoly CPT is greater than 0.5 (monopoly) and smaller than 1 (perfect competition). 0.75, which is a midpoint of this range, is used for the purpose of testing CPT consistent with oligopoly pricing.

5. Estimation Results

5.1. *Wholesale price behavior and farm-to-wholesale price transmission in the U.S. beef industry*

Table 2 summarizes the OLS estimation results and the outcomes of T-tests on statistical significance of fixed absolute markups and cost pass-throughs. Table 4 summarizes the outcomes of additional T-tests on the type of wholesale beef pricing (perfectly competitive pricing or imperfectly competitive pricing) and pricing methods used by beef packers (wholesalers) during the two analyzed periods of interest.

The variation in the explanatory variables (farm value, cartel binary variable, the interaction effect of the farm value and cartel binary variable, and a set of monthly binary variables) explains 93% of the variation in the wholesale beef value. The estimated coefficients have expected signs and magnitude, and many of them are statistically significant from zero.

Pre-cartel period (2010-2014)

The fixed absolute markup is 35.67 cents per pound, and it is statistically greater than zero. The cost pass-through (CPT) is 0.98. The CPT magnitude suggests that an increase (decrease) in farm value of beef by 1 cent per pound causes wholesale value of beef to increase (decrease) by 0.98 cents per pound. Alternatively, an increase (decrease) in farm value of beef by $1.00 per pound causes wholesale value of beef to increase (decrease) by $0.98 per pound. The pre-cartel period cost pass-through (0.98) is complete. The null hypothesis of a perfectly competitive pricing CPT=1 fails to be rejected. The wholesale pricing of beef during pre-cartel period is consistent with a perfectly competitive pricing. This type of pricing reflects a fixed absolute markup pricing method used by beef packers (wholesalers).

Cartel period (2015-2019)

During cartel period, as compared to pre-cartel period, fixed absolute markup increases, and cost pass-through decreases. The estimated changes in fixed absolute markup and cost pass-through are statistically significant from zero. During cartel period, fixed absolute markup is 158.68 cents per pound, and it is statistically greater than zero. The cost pass-through is 0.62. The CPT magnitude suggests that an increase (decrease) in farm value of beef by 1 cent per pound causes wholesale value of beef to increase (decrease) by 0.62 cents per pound. Alternatively, an increase (decrease) in farm value of beef by $1.00 per pound causes wholesale value of beef to increase (decrease) by $0.62 per pound.

The cartel period cost pass-through (0.62) is incomplete. The null hypothesis of a perfectly competitive pricing CPT=1 is rejected in favor of alternative hypothesis of imperfectly competitive pricing CPT<1. Furthermore, the null hypothesis of CPT=0.75 reflecting oligopoly pricing fails to be rejected. The null hypothesis of CPT=0.5 reflecting monopoly pricing fails to be rejected as well. Consequently, wholesale beef pricing during cartel period is consistent with oligopoly and monopoly pricing in a market with linear demand and constant marginal cost. This type of pricing reflects a wholesale price stabilization method used by beef packers (wholesalers).

5.2. Retail price behavior and wholesale-to-retail price transmission in the U.S. beef industry

Table 3 summarizes the OLS estimation results and the outcomes of T-tests on statistical significance of fixed absolute markups and cost pass-throughs. Table 4 summarizes the outcomes of additional T-tests on the type of retail beef pricing (perfectly competitive pricing or imperfectly

competitive pricing) and pricing methods used by food retailers during the two analyzed periods of interest.

The variation in the explanatory variables (wholesale values, cartel binary variable, the interaction effects of the wholesale values and cartel binary variable, and a set of monthly binary variables) explains 99% of the variation in the retail beef value. The estimated coefficients have expected signs and magnitude, and many of them are statistically significant from zero.

Pre-cartel period (2010-2014)

The fixed absolute markup is 119.83 cents per pound, and it is statistically greater than zero. The cost pass-through (CPT) is 1.33. The CPT magnitude suggests that an increase (decrease) in wholesale value of beef by 1 cent per pound causes retail value of beef to increase (decrease) by 1.33 cents per pound. Alternatively, an increase (decrease) in wholesale value of beef by $1.00 per pound causes retail value of beef to increase (decrease) by $1.33 per pound. The pre-cartel period cost pass-through (1.33) is more than complete. The null hypothesis of a perfectly competitive pricing CPT=1 is rejected in favor of alternative hypothesis CPT >1. The retail beef pricing during pre-cartel period is consistent with oligopoly/monopoly pricing in a market with non-linear (convex) demand and constant marginal cost. This type of pricing reflects a fixed percentage markup pricing method used by food retailers.

Cartel period (2015-2019)

During cartel period, as compared to pre-cartel period, fixed absolute markup increases, and cost pass-through decreases. The estimated changes in fixed absolute markup and cost pass-through are statistically significant from zero. During cartel period, fixed absolute markup is 362.41 cents per pound, and it is statistically greater than zero. The cost pass-through is 0.71. The CPT magnitude suggests that an increase (decrease) in wholesale value of beef by 1 cent per pound causes retail value of beef to increase (decrease) by 0.71 cents per pound. Alternatively, an increase (decrease) in wholesale value of beef by $1.00 per pound causes retail value of beef to increase (decrease) by $0.71 per pound.

The cartel period cost pass-through (0.71) is incomplete. The null hypothesis of a perfectly competitive pricing CPT=1 is rejected in favor of alternative hypothesis of imperfectly competitive pricing CPT<1. Furthermore, the null hypothesis of CPT=0.75 reflecting oligopoly pricing fails to be rejected. Consequently, retail beef pricing during cartel period is consistent with oligopoly

pricing in a market with linear demand and constant marginal cost. This type of pricing reflects a retail price stabilization method used by food retailers.

6. Conclusion

The research presented in the paper conducts an econometric analysis of wholesale and retail price behavior in the U.S. beef industry during the period of alleged cartel of the four largest beef packers ("cartel period": 2015-2019) and the prior (more competitive) period ("pre-cartel period": 2010-2014). There is empirical evidence indicating changes in the wholesale and retail price behavior of beef during these two periods.

As for the wholesale price behavior, there was a change in the type of pricing and pricing method used by beef packers (wholesalers) between the pre-cartel and cartel periods. During pre-cartel period, wholesale beef pricing is consistent with a perfectly competitive pricing. During cartel period, wholesale beef pricing is consistent with monopoly and oligopoly pricing in a market with linear demand and constant marginal cost. Consequently, pricing method used by beef packers (wholesalers) shifted from a fixed absolute markup pricing in pre-cartel period to a wholesale price stabilization method in cartel period. A decrease in the volatility of wholesale beef value during cartel period (as compared to pre-cartel period) revealed by the descriptive statistical analysis is consistent with a wholesale price stabilization method.

As for the retail price behavior, while the type of pricing, oligopoly pricing, did not change, the type of pricing method used by food retailers changed between the pre-cartel and cartel periods. During pre-cartel period, retail beef pricing is consistent with oligopoly and monopoly pricing in a market with non-linear (convex) demand and constant marginal cost. During cartel period, retail beef pricing is consistent with oligopoly pricing in a market with linear demand and constant marginal cost. Consequently, pricing method used by food retailers shifted from a fixed percentage markup pricing in pre-cartel period to a retail price stabilization method in cartel period. A decrease in the volatility of retail beef value during cartel period (as compared to pre-cartel period) revealed by the descriptive statistical analysis is consistent with a retail price stabilization method.

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Sherman Act (1890) *15 U.S.C. § 1.*
https://www.law.cornell.edu/uscode/text/15/1

Legal Documents (Complaints)

Complaint filed by R-CALF and cattle producers on April 23, 2019 with the United States District Court, Northern District of Illinois: *Ranchers Cattlemen Action Legal Fund United Stockgrowers of America et al v Tyson Foods, Inc. et al* Case 1:19-cv-02726
https://www.courtlistener.com/recap/gov.uscourts.ilnd.363912/gov.uscourts.ilnd.363912.1.0.pdf

Complaint filed by consumers purchasing beef at the retail level (indirect buyers) on April 26, 2019 with the United States District Court, District of Minnesota: *Peterson et al v. Agri Stats, Inc. et al* Case 0:19-cv-01129
https://www.hbsslaw.com/uploads/case_downloads/beef-antitrust/2019-04-26-hagens-berman-beef-antirust-class-action-lawsuit-complaint.pdf

Complaint filed by a meat wholesaler (direct buyer) on October 16, 2019 with the United States District Court, District of Minnesota: *Pacific Agri-Products v. JBS USA Food Company Holdings et al* Case 0:19-cv-02720
https://www.courtlistener.com/recap/gov.uscourts.mnd.183132/gov.uscourts.mnd.183132.1.0.pdf

Table 1. U.S. Beef Industry Farm, Wholesale and Retail Values of Beef, Farm Sector Share and Margins: Descriptive Statistics (2010-2019).

Variable/Formula	Unit of measurement	Pre-cartel period (2010-2014)		Cartel period (2015-2019)		Change in the cartel period, relative to the pre-cartel period	
		Average	CV	Average	CV	Average (%)	CV (%)
Farm Value (FP)	Cents per pound	260.06	0.17	273.99	0.12	13.9 (5.4)	-0.04 (-25.6)
Wholesale Value (WP)	Cents per pound	294.13	0.14	334.21	0.08	40.1 (13.6)	-0.06 (-44.2)
Retail Value (RP)	Cents per pound	509.38	0.11	602.57	0.03	93.2 (18.3)	-0.08 (-70.2)
Farm-to-Wholesale Margin: WP-FP	Cents per pound	34.07	0.23	60.22	0.34	26.1 (76.7)	0.11 (47.8)
Farm-to-Wholesale Margin: [(WP-FP)/WP]*100%	% of wholesale value	11.83	0.27	18.12	0.34	6.3 (53.2)	0.07 (25.9)
Farm-to-Wholesale Margin: [(WP-FP)/RP]*100%	% of retail value	6.78	0.26	10.02	0.34	3.2 (47.6)	0.08 (32.8)
Wholesale-to-Retail Margin: RP-WP	Cents per pound	215.25	0.08	268.36	0.06	53.1 (24.7)	-0.02 (-25.7)
Wholesale-to-Retail Margin: [(RP-WP)/RP]*100	% of retail value	42.44	0.06	44.59	0.07	2.1 (5.1)	0.01 (17.2)
Farm Sector Share: [FP/RP]*100%	% of retail value	50.77	0.06	45.39	0.10	-5.4 (-10.6)	0.04 (57.1)

Number of observations is 60 in each of the analyzed periods. CV is the coefficient of variation (=standard deviation/average).
The averages and coefficients of variation are calculated by the author using farm, wholesale and retail values of beef reported in USDA ERS (2020).

Table 2. U.S. Beef Industry: *Wholesale* Beef Price Behavior (2010-2019): OLS Estimation Results.

Variable	Coefficient	Estimated Coefficient	T-Ratio
FP_t	β_0	0.98*	40.48
C_t	α_1	123.01*	6.38
FP_tC_t	γ_0	-0.35*	-5.41
February		-7.80*	-2.34
March		4.19	1.14
April		5.08	1.19
May		14.95*	3.75
June		17.30*	4.02
July		7.75*	2.07
August		9.55*	1.78
September		4.33	0.91
October		-0.86	-0.18
November		1.50	0.25
December		-2.97	-0.76
Constant	α_0	35.67*	5.47
R2		0.93	
DW-Statistic[1]		0.72	
F-Test (Seasonality) p-value		0.0000	
Pre-cartel period (2010-2014)			
Fixed Absolute Markup	α_0	35.67*	5.47
Cost Pass Through	β_0	0.98*	40.48
Change between pre-cartel period and cartel period			
Fixed Absolute Markup	α_1	123.01*	6.38
Cost Pass Through	γ_0	-0.35*	-5.41
Cartel period (2015-2019)			
Fixed Absolute Markup	$\alpha_0+\alpha_1$	158.68*	8.44
Cost Pass Through	$\beta_0+\gamma_0$	0.62*	10.24

[1] T-ratios are calculated using autocorrelation-adjusted standard errors based on Newey-West approach.
* The estimated coefficient (EC) is statistically significant from zero at the 10% significant level using a two-tailed T-test. Ho: EC=0, and Ha: EC≠0; the T statistic rejection regions are (-∞; -1.66] and [1.66; +∞). The number of observations is 120.

Table 3. U.S. Beef Industry: *Retail* Beef Price Behavior (2010-2019): OLS Estimation Results.

Variable	Coefficient	Estimated Coefficient	T-Ratio
WP_t	β_0	0.36[*]	3.90
WP_{t-1}	β_1	0.48[*]	4.64
WP_{t-2}	β_2	0.49[*]	4.96
C_t	α_1	242.59[*]	19.50
$WP_t C_t$	γ_0	-0.17[b]	-1.63
$WP_{t-1} C_t$	γ_1	-0.27[*]	-2.41
$WP_{t-2} C_t$	γ_2	-0.17[b]	-1.41
February		3.58[a]	1.40
March		6.77[*]	1.95
April		7.25[*]	2.33
May		1.13	0.37
June		1.57	0.40
July		1.18	0.34
August		3.95	1.10
September		3.55	1.06
October		1.65	0.43
November		7.25[*]	2.37
December		0.34	0.13
Constant	α_0	119.83[*]	19.47
R2		0.99	
DW-Statistic[1]		0.74	
F-Test (Seasonality) p-value		0.0913	
Pre-cartel period (2010-2014)			
Fixed Absolute Markup	α_0	119.83[*]	19.47
Cost Pass Through[2]	$\beta_0+\beta_1+\beta_2$	1.33[*]	70.33
Change between pre-cartel period and cartel period			
Fixed Absolute Markup	α_1	242.59[*]	19.50
Cost Pass Through[2]	$\gamma_0+\gamma_1+\gamma_2$	-0.62[*]	-16.52
Cartel period (2015-2019)			
Fixed Absolute Markup	$\alpha_0+\alpha_1$	362.41[*]	30.89
Cost Pass Through[2]	$\beta_0+\beta_1+\beta_2+\gamma_0+\gamma_1+\gamma_2$	0.71[*]	21.13

[1] T-ratios are calculated using autocorrelation-adjusted standard errors based on Newey-West approach.

[2] Cost Pass Through is a cumulative cost pass through.

[*] The estimated coefficient (EC) is statistically significant from zero at the 10% significant level using a two-tailed T-test. Ho: EC=0, and Ha: EC≠0; the T statistic rejection regions are (-∞; -1.66] and [1.66; +∞).

[a] The estimated coefficient (EC) is statistically significant from zero at the 10% significance level using a one-tailed T test. Ho: EC=0, and Ha: EC>0; the T statistic rejection region is [1.29; +∞).

[b] The estimated coefficient (EC) is statistically significant from zero at the 10% significance level using a one-tailed T test. Ho: EC=0, and Ha: EC<0; the T statistic rejection region is [-1.29; +∞).

The number of observations is 120.

Table 4. U.S. Beef Industry: Wholesale and Retail Pricing (2010-2019).

	Wholesale pricing	Retail pricing
Pre-cartel period (2010-2014)		
Fixed Absolute Markup	**35.67**	**119.83**
Cost Pass Through (CPT)	**0.98** Ho: CPT = 1 fails to be rejected (T statistic = -0.96)	**1.33** Ho: CPT = 1 is rejected in favor of Ha: CPT>1 (T statistic = 17.34)
Economic model	**Perfectly competitive pricing**	**Oligopoly/Monopoly pricing** [non-linear demand, constant marginal cost]
Pricing method	**Fixed absolute markup**	**Fixed percentage markup:** **wholesale-to-retail margin** **stabilization**
Cartel period (2015-2019)		
Fixed Absolute Markup	**158.68**	**362.41**
Cost Pass Through (CPT)	**0.62** Ho: CPT = 0.75 fails to be rejected (T statistic = -2.06) Ho: CPT = 0.50 fails to be rejected (T statistic = 2.04)	**0.71** Ho: CPT = 0.75 fails to be rejected (T statistic = -1.27)
Economic model	**Oligopoly pricing** **Monopoly pricing** [linear demand, constant marginal cost]	**Oligopoly pricing** [linear demand, constant marginal cost]
Pricing method	**Wholesale price stabilization**	**Retail price stabilization**

The null and alternative hypotheses on the types of pricing methods are explained in Table II.
T-statistic cut-off value used to conduct T-tests presented in this table is |2.66| (one-tailed T-test and 1% significance level).
The fixed absolute markups are statistically greater than zero (Tables 2 and 3).
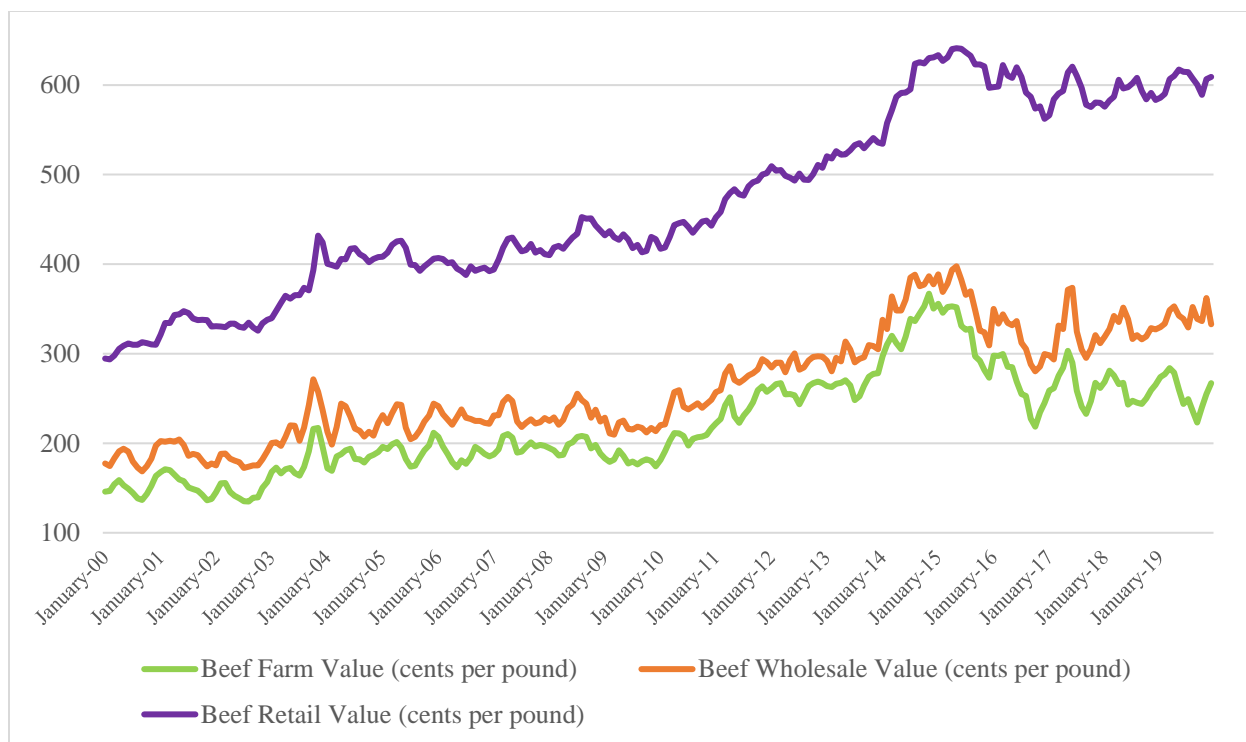The fixed absolute markups and cost pass-throughs are from Tables 2 and 3.

Figure 1. U.S. Beef Industry: Farm Value, Wholesale Value and Retail Value of Beef (2000-2019: monthly data). *Data source is USDA ERS (2020).*
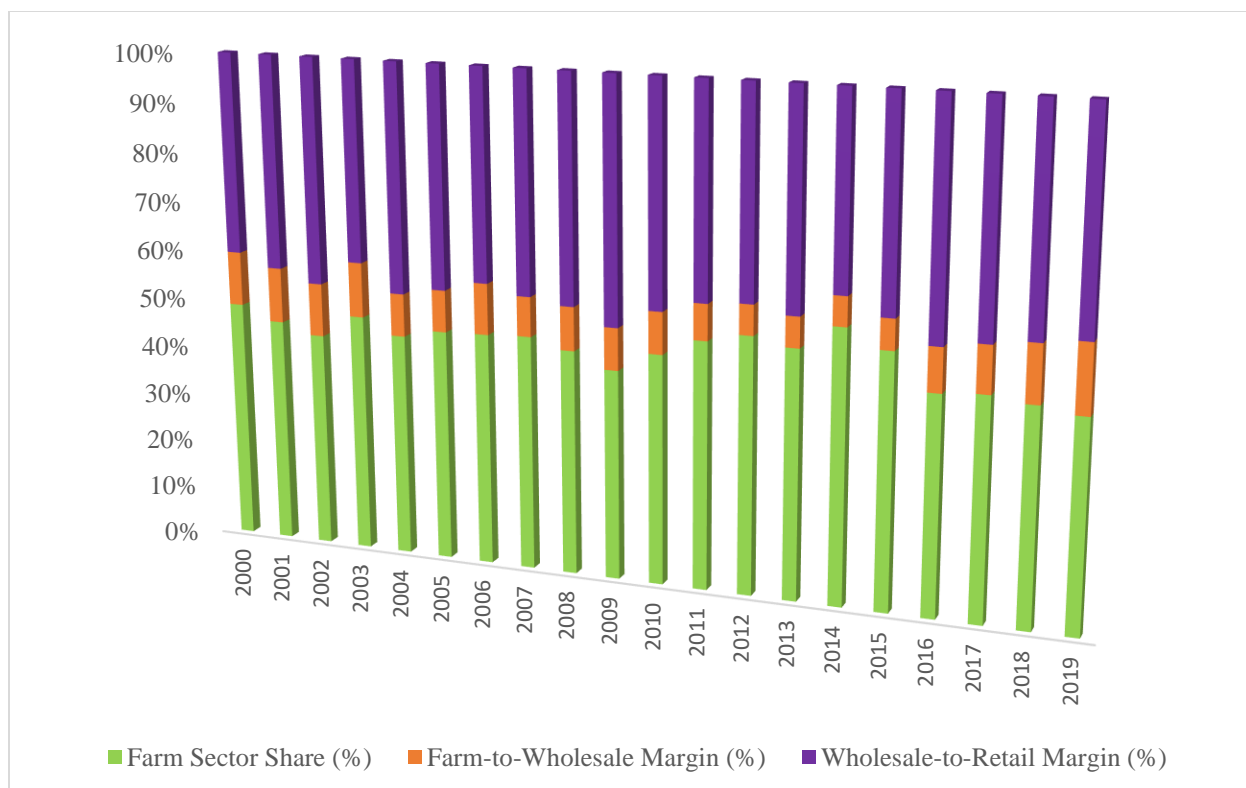
Figure 2. U.S. Beef Industry: Farm Sector Share, Farm-to-Wholesale Margin and Wholesale-to-Retail Margin as a Percentage of the Retail Value (2000-2019: yearly data).

The measures depicted in the figure are calculated by the author using farm, wholesale and retail values of beef reported in USDA ERS (2020).

Appendix. U.S. Beef Industry: Descriptive Statistics (2000-2019).

Variable	Unit of measurement	Average	Standard Deviation	Variance	Minimum	Maximum
2000-2014 (N=180)						
Farm Value	Cents per pound	204.56	49.72	2471.70	134.90	367.00
Wholesale Value	Cents per pound	240.32	49.04	2404.50	168.60	388.20
Retail Value	Cents per pound	425.62	76.24	5812.00	293.60	631.00
Farm-to-Wholesale Margin	Cents per pound	35.75	7.30	53.28	17.30	56.90
Farm-to-Wholesale Margin	% of wholesale value	15.43	4.00	15.99	5.02	24.47
Farm-to-Wholesale Margin	% of retail value	8.69	2.34	5.47	3.08	14.51
Wholesale-to-Retail Margin	Cents per pound	185.30	32.60	1062.90	112.50	253.50
Wholesale-to-Retail Margin	% of retail value	43.63	3.43	11.74	30.97	51.69
Farm Sector Share	% of retail value	47.68	3.77	14.24	40.33	58.23
2010-2014 (N=60)						
Farm Value	Cents per pound	260.06	43.34	1877.90	181.20	367.00
Wholesale Value	Cents per pound	294.13	42.59	1813.90	220.40	388.20
Retail Value	Cents per pound	509.38	55.72	3104.40	417.30	631.00
Farm-to-Wholesale Margin	Cents per pound	34.07	7.90	62.49	17.30	51.70
Farm-to-Wholesale Margin	% of wholesale value	11.83	3.16	9.98	5.02	18.52
Farm-to-Wholesale Margin	% of retail value	6.78	1.76	3.08	3.08	10.77
Wholesale-to-Retail Margin	Cents per pound	215.25	17.55	308.04	186.50	253.50
Wholesale-to-Retail Margin	% of retail value	42.44	2.60	6.74	35.29	47.21
Farm Sector Share	% of retail value	50.77	3.27	10.70	43.42	58.23
2015-2019 (N=60)						
Farm Value	Cents per pound	273.99	33.97	1153.80	218.50	355.70
Wholesale Value	Cents per pound	334.21	27.02	730.20	280.20	397.60
Retail Value	Cents per pound	602.57	19.64	385.90	562.20	641.20
Farm-to-Wholesale Margin	Cents per pound	60.22	20.65	426.27	23.10	116.40
Farm-to-Wholesale Margin	% of wholesale value	18.12	6.08	36.95	6.26	34.14
Farm-to-Wholesale Margin	% of retail value	10.02	3.44	11.85	3.68	19.26
Wholesale-to-Retail Margin	Cents per pound	268.36	16.27	264.59	242.50	298.50
Wholesale-to-Retail Margin	% of retail value	44.59	3.20	10.22	37.99	51.16
Farm Sector Share	% of retail value	45.39	4.60	21.12	37.16	56.17